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Trends that are being followed in solving

Problems of Steel Mill Operation

involving the use of electrical and mechanical power drive equipment, together with present tendencies in the conversion, distribution and application of electrical energy in the iron and steel industry

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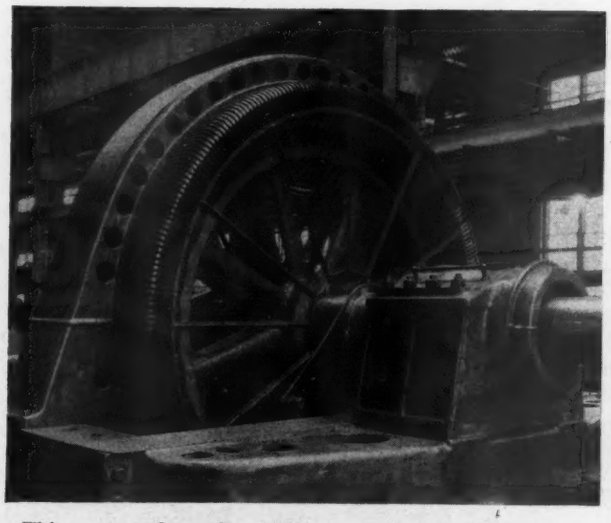
IN THE application of electric motors to steel mill main roll drives, there has been great activity during the past nine months. During the period Aug. 1, 1924, to Aug. 1, 1925, 105 motors totaling 236,375 hp. were sold for application to steel mill main roll drives. From Aug. 1, 1925, to May 1, 1926, 84 motors totaling 135,480 hp. have been purchased by the steel industry for its main roll drives. A list of the motors together with the names of the companies purchasing them is given on page 250.

The record of the past 1¾ years is certainly convincing proof that electric motors are now recognized throughout the steel industry as the standard for mill drives. Not only has their former competitor, the steam engine, ceased to be a competitor, but steam engines in existing mills are being replaced in ever-increasing numbers by modern electrical equipment. Companies in which extensive replacements of steam drive are under way are the Inland Steel Co., Carnegie Steel Co., Kokomo Steel Co., Colorado Fuel & Iron Co., and the Bethlehem Steel Co.

An interesting trend is the increased use of "frog leg" windings on large direct-current machines used in the steel industry. Since their introduction only a short time ago, 30 motors totaling 36,865 hp. have been sold to ten steel companies. It is interesting to note that a new 7,000-hp. reversing motor, which will be installed in the Chicago district, will have this winding on it; also that a 4,500-hp. motor with this type of winding has just recently been placed in operation in a skelp mill of a large pipe manufacturer.

The use of synchronous motors for main roll drives has received a decided impetus. A number of motors of this type have been used on seamless tube mills. The Globe Steel Tubes Co. has a 2,500-hp. unit. Also, a new seamless tube mill that is to be built in the Chicago district will have an 1,800-hp. synchronous motor on its main drive. An application of this character of especial interest is the motor now being erected by the McKinney Steel Co., which will drive a 10-stand, Morgan continuous sheet bar mill. This is a 9,000-hp. unity-power-factor, 107-r.p.m., 6,600-volt, 25-cycle synchronous motor, shown below, which, from the standpoint of continuous horsepower capacity, is the largest motor of any type used for industrial purposes in the United States or, so far as can be learned, in any other country. It is also notable in that it is the first really large synchronous motor to be used for driving a rolling mill. The motor may be started, stopped, or reversed from a master switch and automatic control panels exactly the same as any other type of rolling mill motor.



This motor has the highest continuous horsepower rating of any industrial motor in the world.

It is a General Electric synchronous motor rated at 9,000 hp., 6,600 volts, 107 r.p.m. and will drive a 10-stand Morgan continuous sheet bar mill for the McKinney Steel Co., Cleveland, Ohio. It is the largest synchronous motor in such service.

Important developments have occurred in the control of variable-speed, direct-current, compound-wound motors. Modern mills for the rolling of strip, skelp, rod, and merchant shapes, often consist of several groups of one or more roll stands, each group being driven by an individual,

direct-current, adjustable-speed motor. The cross-section of the steel is small, so that to conserve heat, the mills must be operated at high speeds, and the length of the piece is such that it may be in several roll stands simultaneously and for periods of several seconds. This makes necessary the very close speed regulation of the several driving motors in order to avoid excessive looping of the metal in between two stands. For this exacting service compound-wound, compensated, direct-current, adjustable-speed motors are being applied. For machines having a very wide speed range by shunt field adjustment, it is found that adjustment of the series field strength is required in order to have the same speed regulation at all speed settings. In several instances this adjustment has been made by resistance shunts across the series winding cut in or out by means of knife switches or contactors. Recently a scheme has been perfected whereby the compounding excitation is provided by an auxiliary field winding energized from a small exciter generator which is excited by the main armature current, thus exciting the main motor in proportion to its load. In this auxiliary field circuit there is used a multi-point rheostat which is mechanically connected to the operating mechanism of the main shunt field rheostat. Thus the compounding excitation is adjusted simultaneously with the main shunt excitation and by proper proportioning of the field resistances the speed regulation may be made practically flat for all speed settings.

Adjustable-speed motors are used on main roll drives in strip mills and quite a few strip mills are now under construction. One of particular interest is the 16-20-in. strip mill now nearing completion in one of the mills in the Chicago district. In this mill there are 14 roll stands, two of which are edging stands. The first four stands are roughing units and are driven through a lineshaft and reduction gear set by a 1,500-hp., 2,200-volt, wound-rotor induction motor. The two intermediate stands are driven through reduction gears by 1,500-hp., and 1,800-hp. 600-volt, direct-current, adjustable-speed motors. The remaining four finishing stands are individually driven by 1,800-hp., 600-volt, direct-current, adjustable-speed motors.

Each of the above-mentioned gear sets is composed of Sykes herringbone gears which are connected to the Westinghouse driving motors by means of Falk-Bibby flexible couplings. These gears run in oil that is fed to them under pressure and filtered by means of a Bowser lubrication system.

Very good use is made of the basement in connection with the ventilation and cooling of the motors and motor-generator sets. Instead of running individual air ducts to each motor and generator, it was found to be decidedly cheaper and just as efficient to put the whole basement under pressure, sealing all outlets except the places at which the busbars enter the motors and generators. These places are left open so that the basement air being under pressure will pass up through the

Motor-Driven Main Drives Purchased During Past Nine Months

Company	Mill	Drive	Motors No.	Motors Hp.	Volts	Cycles	R.P.M.
Bethlehem Steel Co.	Sheet Mill	Geared	1	1,250	6,600	25	250
	Tin Plate	Geared	3	1,250	6,600	25	250
Buffalo Steel Co.	Rail Rerolling	Direct	2	1,350	4,400	25	214/161
Carnegie Steel Co Youngstown, Ohio.	Hoop Mill	Geared	2	450	6,600	25	730
	Hoop Mill	Geared	2	700	6,600	25	490
	Hoop Mill	Geared	1	1,600	6,600	25	490
	Hoop Mill	Geared	1	770	6,600	25	440/540
	Hoop Mill	Geared	2	1,600	6,600	25	440/540
Carnegie Steel Co. Homestead, Pa.	52-in. Structural	Direct	2	2,000	700	d.c.	57/163
Colorado Fuel & Iron Co.	10-in. Merchant	Direct	1	300	600	d.c.	175/225
	Structural	Geared	1	3,000	6,600	60	450
	Structural	Geared	1	2,000	6,600	60	450
Columbia Steel Co.	Rev. Hot Strip	Direct	1	5,000	900	d.c.	70/150
	Hot Strip	Geared	4	2,000	600	d.c.	200/400
Conners Steel Co.	16-in. Mill	.....	1	700	2,300	60	440
Crucible Steel Co.	22-in. Merchant	Geared	1	1,800	250	d.c.	550/650
	9-in. Merchant	Direct	1	700	250	d.c.	240/450
	9-in. Roughing	.....	1	800	250	d.c.	200/450
	9-in. Roughing	Geared	1	500	2,200	60	884
	Bar & Billet	Geared	1	400	2,200	60	885
Donner Steel Co.	Bar	Geared	1	1,000	230	d.c.	210/510
Ford Motor Co.	18-in. Cont. Billet	Direct	1	5,000	13,200	60	99
Forged Steel Wheel Co.	40-in. Rev. Blooming	Direct	1	7,000	700	d.c.	50/120
Globe Steel Tubes Co.	Piercing	.....	1*	2,500	2,200	60	257
Illinois Steel Co. Chicago, Ill.	Blooming Mill	.....	1	7,000	700	d.c.	50/120
	12-in. Bar	Geared	3	500	600	d.c.	175/350
	12-in. Bar	Geared	5	1,000	600	d.c.	350/700
	12-in. Bar	Direct	2	800	600	d.c.	175/350
	12-in. Bar	Direct	3	800	600	d.c.	220/440
Inland Steel Co.	Rail Rerolling	Direct	2	1,000	4,000	60	225/168
	Rail Rerolling	Direct	1	400	4,000	60	514
	Sheet Bar	Geared	1	3,000	2,200	25	500/250
	19-in. Cont. Billet	Geared	1	7,500	2,200	25	368
Indiana Rolling Mill Co.	22-in. Finishing	Geared	2	300	2,200	60	505
Latrobe Electric Steel Co.	Merchant	Geared	1	400	440	60	870
	10-in. Merchant	Geared	1	500	440	60	900
McKinney Steel Co.	10-in. Merchant	Geared	1	1,000	600	d.c.	200/600
	10-in. Merchant	Direct	1	2,000	600	d.c.	134/275
	10-in. Merchant	Direct	1	1,200	600	d.c.	300/500
	12-in. Merchant	Direct	1	5,610	6,600	25	156/94
	12-in. Merchant	Direct	3	800	600	d.c.	200/415
	12-in. Merchant	Direct	1	800	600	d.c.	240/480
Penn Seaboard Steel Co.	12-in. Merchant	Geared	2	800	700	d.c.	275/550
	9-in. Merchant	Direct	1	800	700	d.c.	275/550
Pittsburgh Crucible Steel Co.	18-in. Roughing Mill	.....	1	1,800	500	d.c.	350/640
	18-in. Merchant	Geared	1	600	250	d.c.	400/800
	12-in. Merchant	Direct	1	1,200	250	d.c.	160/320
	12-in. Merchant	Direct	1	500	250	d.c.	175/350
Sharon Steel Hoop Co.	Strip	Direct	2	1,200	230	d.c.	200/400
Southern Cal. Iron & Steel Co.	Merchant	Direct	1	1,500	2,200	50	300/175
Standard Seamless Tube Co.	Piercing	Geared	1	3,500	2,200	60	600
	Tube Rolling	Geared	1	1,600	2,200	60	600
Wheeling Steel Corp.	Sheet	Geared	1	1,200	2,200	60	277
Youngstown Sheet & Tube Co., Youngstown, Ohio.	Seamless Tube	Geared	1	2,000	600	d.c.	230/360
	Seamless Tube	Geared	4*	450	2,200	60	720
Youngstown Sheet & Tube Co., Indiana Harbor, Ind.	Tin Mill	.....	1	1,800	2,200	60	253
	Cold Roll	.....	2	1,000	2,200	60	235
MILLS FOR METALS OTHER THAN STEEL							
American Brass Co.	Brass & Copper	Geared	1	600	550	60	360
	Brass & Copper	Geared	1	600	550	60	300
Anaconda Copper Mining Co.	Copper	Direct	1	800	2,200	60	450/225
	Copper	Direct	1	500	2,200	60	450
Mich. Copper & Brass Co.	Rev. Hot Copper	Geared	1	500	600	d.c.	360/612
	Copper Rolling	.....	5*	800	4,600	60	720
The International Nickel Co.	Cold Strip	.....	5	320	230	.....	400/800
U. S. Aluminum Co.	Aluminum	Geared	1	500	2,200	25	500

* Indicates Synchronous Motor. For drives purchased prior to Aug. 1, 1925, see page 408 of the September, 1925, issue of INDUSTRIAL ENGINEER.

motors or generators and out into the atmosphere of the room above. Two blowers are located in an outhouse on the ground level of the floor above, which force air through Reed dry-type air filters into the basement.

An unusually interesting installation is being completed in the combination cross country and structural mill of a Chicago independent producer. The mill will have a reversing drive on two stands in tandem and three adjustable-speed drives on other tandem roll trains. The reverse drive is the standard arrangement using a 3,100-hp. motor supplied from a flywheel motor-generator set. There are two generators on this set, one of which supplies the reversing motor while the other supplies the three 2,000-hp. adjustable-speed motors.

A feature of the control on the main motor is the fact that a special master has been built, which controls not only the reversing motor, but also the front and back mill tables. Cutouts are arranged for foot operation so that any of the above may be cut out and the remainder run separately. For instance, it might be desired to run the tables without the reversing motor so as to get the bar close to the roll train. In such cases the operator pushes a cutout switch with his foot, which cuts out the control of the main motor temporarily.

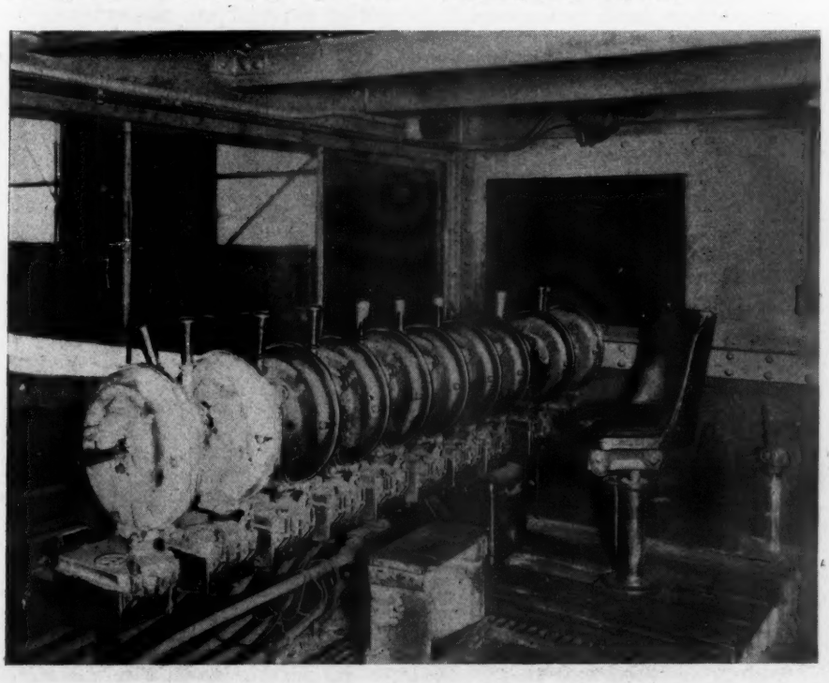
Improvements have been made in alternating-current, adjustable-speed drives by the development of a frequency converter type of equipment, arranged for double-range operation and having constant-torque characteristics. The main induction motor and the frequency converter, both on the same shaft, are the only two rotating machines required. The induction motor slip energy is converted to line frequency directly by the frequency converter, and returned to the line through speed-adjusting transformers. Three machines of this type, one of 770 hp. and two of 1,600 hp. each, are being built for hoop mill drives at the Upper Union Works of the Carnegie Steel Co.

A 3,500-hp., 700-volt, 50-120-r.p.m. reversing motor which replaced a steam engine on the 34-in. blooming mill at the Kokomo Steel and Wire Co., Kokomo, Ind., was put into operation during December, 1925. An interesting feature of this installation is the use of a large Falk-Bibby type of flexible coupling to connect the motor to the pinion stand. It is also of interest to note that air for the ventilation of the reversing motor is cleaned by a Midwest type of air filter of 30,000 c.f.m. capacity. Heretofore wet air washers have been used for this service, but there seems to be a growing interest by steel mill operators in the dry type of filter.

The McKinney Steel Co. of Cleveland, Ohio, will install five motors for driving a new 12-in. merchant mill. The roughing stands will be driven by the largest Scherbius equipment which has so far been built. The motor is rated 5,610/4,500/3,370 hp., 156/125/93.6 r.p.m., 6,600 volts, 25 cycles.

Confirmation of some of the present trends in the use of steel mill main drives is noted in the types of the 72 main drive motors sold by one manufacturer during the year 1925. Out of the total number of motors, 46 per cent were direct-current, adjustable-speed motors. In other words, 79 per cent of the main drive motors fell in these two classifications. This clearly indicates the trend in main drive motors. Also, out of the 32 alternating-current, constant-speed, main drive motors sold, 70 per cent of them were for 60-cycle service thus clearly indicating the trend toward the use of 60-cycle power in the steel mills.

An interesting trend which has been but slightly touched upon previously in this article is the use of dry-type air filters instead of the more common air washer for purifying the cooling air supply for motors and generators. Although the wet washer cools the air as well as cleans it (which is of advantage during the hot summer months) several engineers stated that they favored the dry-type air filter because it possesses greater simplicity.



Operator's pulpit in a modern 40-in. motor-driven, reversing blooming mill.

The roller sits in the chair and controls the main drive motor from a foot-operated master switch. With his hands he controls the screwdown and main tables. A second man controls all of the remaining equipment. The master switches shown are of the Westinghouse plug type, which may be removed and replaced with a spare by loosening three wing nuts.

Changes in Auxiliary Drive Equipment

The attempt to standardize mill-type motors as used on auxiliary drives is absorbing the interest of many steel mill engineers. For a number of years it has been considered desirable that all mill-type motors of a given size should have uniform mounting dimensions so that complete motors of different manufacture would be interchangeable.

With this object in view the Standardization Committee of the Association of Iron and Steel Electrical Engineers has met with representatives of the manufacturers of mill-type motors. This committee stated that the differences in the external dimensions of mill-type motors of different manufacture was so slight that the problem of standardizing the external dimensions should not be difficult. This committee also proposed to the manufacturers that the

present eleven frame sizes be reduced to eight.

Another consideration was whether the motor speeds should be increased. A questionnaire sent by the committee to the membership of the Association disclosed, however, that the present low speeds were strongly favored. Another point raised in the questionnaire was whether or not anti-friction bearings should be accepted as standard for mill-type motors. Replies indicated that those who had extensive experience with anti-friction bearings strongly favored their adoption while the majority of replies, based on numbers, indicated that motors equipped with sleeve as well as anti-friction bearings would be in demand.

At the Chicago Convention of the Association it is expected that a final agreement will be reached in regard to the points mentioned above as well as on the following: (1) Should mill-type motors be provided with bearings having sufficient thrust capacity to permit the use of single-spiral 7 to 10 deg. helical gearing? (2) Should the mill-type motor be arranged to permit the use of sleeve type or anti-friction bearings interchangeably in the same frame? (3) Should the armatures be built on a spider with a commutator mounted on an extension thereof? (4) Determination of standard sizes for shaft diameters, tapers, keys, keyways, and shaft tolerances.

The use of mill-type motors on adjustable speed drives is increasing. One plant visited in the Chicago district is using mill-type motors exclusively on the drives smaller than 100 hp. in the welding end of its pipe mills. Motors in this part of the mill receive very severe service and are subjected to a great deal of dirt and dust and necessarily ought to be totally enclosed. Many of the drives in a pipe mill must have the speed controlled according to the size of product rolled. Consequently, general-purpose, shunt-wound motors have been commonly applied in the past for such applications. In the plant visited a special, compound-wound, mill-type motor is in use. These motors have a greater percentage of shunt field and a smaller percentage of series field than is the case with the standard compound-wound, mill-type motor. In many applications in a pipe mill, particularly so in the case of the cross rolls, close adjustment of the speed is required and this was being obtained with the motors just described.

This type of motor is also being installed in a new combination cross country and structural mill now being erected by a Chicago independent producer. Eight motors rated at 40-60 hp., 650-1,350 r.p.m. are being used to drive mill tables. The speed of the tables has to be varied in accordance with the speed of the main drives, which varies with the size of product rolled.

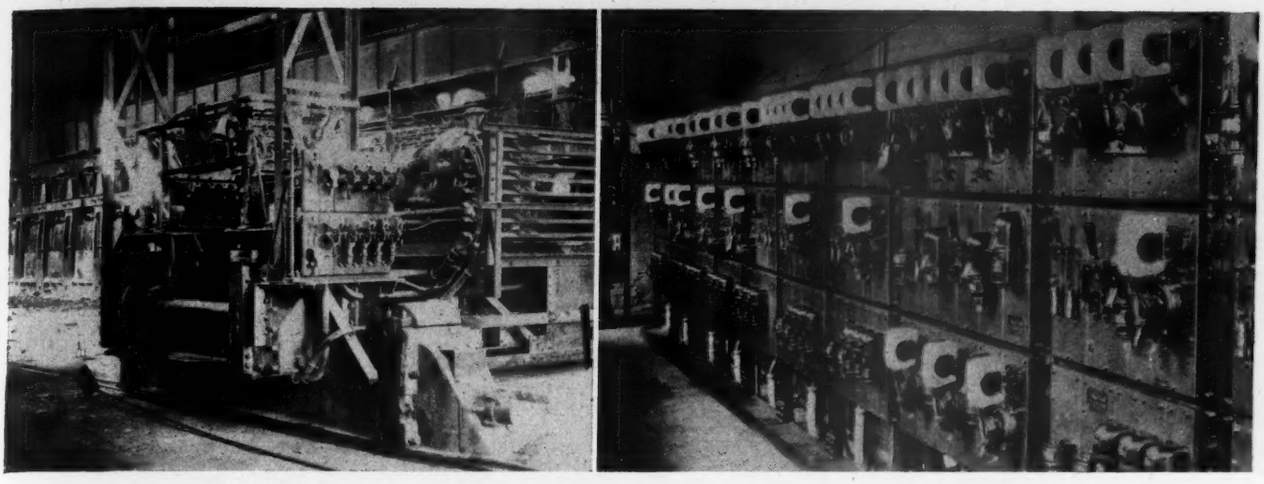
Another interesting auxiliary drive is the use of 95, ½-hp. squirrel-cage motors on the final run-out table in a new strip mill being erected in one of the mills in the Chicago district. Each roller in the table is driven by a separate motor and both the motors and the rollers run on ball bearings. The power for these motors is supplied from a generator that is belted to the last finishing stand main drive. By this arrangement the generator frequency always bears a definite relation to the speed of the last main drive, which in turn causes the table speed to automatically adjust itself in time with the main drive.

The use of complete spare panels with transfer switches for quickly connecting them in circuit finds favor in some quarters.

This installation of General Electric magnetic time-limit control panels in the 35-in. structural mill of the Lackawanna plant of the Bethlehem Steel Co. is so arranged. As may be seen, four-pole, double-throw switches are placed on the bottom panels for transferring both the power and control circuits from the regular to the spare panel. The right-hand illustration shows a rear view of similar panels. No bus is used on this installation, power being brought in through the conduits terminating at the center of the panels. The resistor leads are carried open to a balcony directly overhead, while the transfer leads are carried in the horizontal conduit about a foot above the floor. The conduits terminating at the floor level are for the motor and master switch leads.

Trends in Installation and Use of Motor Control

The question of what type of acceleration should be used for mill motor control is still a live one in steel mill circles. Although several methods have been developed, no one method is being adopted to the exclusion of the others. This is due to the fact that steel mill engineers have had considerable trouble with a method of control developed several years ago—most of which by the way, was due to incorrect application rather than to incorrect design—and as a result are conservative re-



Two sturdy-looking installations of steel mill control.

At the left is an installation of Cutler-Hammer inductive time-limit control on an open hearth, floor-type, charging crane. The right-hand illustration shows an Electric Controller & Mfg. Co. installation in the new charcoal iron mill of the Reading Iron Co.

garding new methods of control. Probably the most widely used method of control at the present time is the current-limit type using series accelerating relays and shunt contactors. Practically all control manufacturers make this type of control and the newer types that they have brought out were developed with the idea of obtaining refinements that they felt should be expected from a motor controller. One manufacturer of both time and series relay control states that he notes a large increase in the sale of his new time-limit controllers, indicating a swing-over in favor of this type of acceleration, but on the other hand he has not noticed a falling off in the volume of sales in his series relay control. This is probably due to the increased volume of business over that of previous years rather than an increased demand for this type of control.

The time-limit method of acceleration has a large following—some plants prefer it to the exclusion of other types. This type of equipment is now made in both the dashpot and the magnetic types. The dashpot type, being the first method developed using the time-limit principle is consequently widely used. The magnetic and the inductive types are more recent developments but are rapidly receiving recognition among the mill operators and even now probably have a wider use than the dashpot type.

The inductive time-limit type, however, is more than a straight time-limit method of acceleration. This type of controller is said to give positive, time-limit acceleration until the motor armature starts to revolve after which current-limit features combine with time limit to govern the acceleration. For this reason it is said that with this type of control the inrush and accelerating currents can be set for minimum or average load, thereby reducing the heating of the motor and limiting the breaking of the heavy current by line contactors. Another feature claimed for this type of control is that it is impossible for a stalled motor to remain on the line, and that the plugging contactor is positively locked out until the motor armature comes to rest. It is also pointed out that with this type of control it is possible to adjust accurately the acceleration current and time at the factory.

Increasing use is found in the case of the magnetic type of time-limit control. In the Chicago district alone sales approximating $50,000 have been made of this type of control for use in the plants of two companies.

A noticeable tendency in application of motor drives is the growing use of two or more motors in parallel and connected together mechanically. These duplex drives are used on screwdowns, mill tables, on the bridge drives of ladle cranes, charging machines, and trolley and bridge drives of ore bridges. The advantages of the duplex system of control for these drives are being recognized.

Briefly, this system uses reversing and accelerating contactors of double-pole construction, each pole controlling the circuit to one of the two motors, and using separate acceleration resistors so that the motor circuits are kept entirely separate. Duplex control so designed is said to provide uniform peaks of current during acceleration and to cause the motors to divide the load evenly while running. The use of separate resistors also prevents destructive circulating currents when the motors are plugged.

This same system has also been extended to control four motors operating in parallel. Such is the case when four motors on the four legs of an ore bridge must be accelerated in exactly the same time so as to give an even operation. This is obtained by the use of four-pole contactors. The Electric Controller & Mfg. Co. has used this scheme of control on the bridge motion of the ore bridge just completed at the Indiana Harbor plant of the Inland Steel Co. and also on an ore bridge that has just been completed at the Central Furnace Co. plant.

The enclosing and housing of control equipment is receiving more attention than formerly. Where it is possible to group together the controllers for a given section of a mill, a control house is built and the controllers mounted therein, either on two separate floors or on one floor with a balcony for the resistors, as shown at the bottom of page 252. This method, while affording the most protection to the equipment and making it most accessible for inspection and maintenance, is quite expensive and often involves more wiring and longer conduit runs than if the controller were located nearer the motor. At the newest plant in the Chicago district, the control panels are located as near the motors as practicable, only the master switches being grouped in the various pulpits. The control panels, however, are totally enclosed in substantial steel cabinets with large doors at the front and rear. These cabinets are large enough to receive the resistors which

are placed on the floor below and immediately behind the panels. This method of installation provides a cheaper alternative than the control house scheme and yet affords good protection to the equipment and safety to the mill workmen.

In many mills it has been the more usual practice to install the control panels for the hoist and bridge motions of a crane in the crane cab. This, of course, necessitates a larger crane cab than would otherwise be necessary, but has the advantage of having the panels close to the master and at the point from which the cranes are controlled. However, a crane cab costs money and an enlargement to take care of the panels is somewhat expensive. Also, the space available in the crane cab is held down to the smallest amount needed to take the control and, consequently, the control panels might be somewhat cramped for space. On all of the cranes used inside of the buildings of a large pipe manufacturer in the Chicago district the standard practice is to locate the crane hoist and bridge control panels on the bridge walkway of the crane, where there is ample room for them.

The illustration shown on page 251 is a view of the operator's pulpit for a new 40-in. electrically-driven reversing blooming mill. The roller controls the screwdown and main tables by means of three master switches, and also controls the main reversing motor by means of a foot-operated master controller. The second operator controls the side guards, manipulators, and approach and run-out tables. The use of foot-operated master controllers reduces the pulpit crew of a blooming mill from three to two men, and also permits of increased production as the concentration of control in two men more closely co-ordinates the many operations involved.

The illustration just mentioned also shows the use of plug-type master switches. The receptacle into which these masters are plugged is arranged for rigidly mounting at the back of an angle or channel section. This leaves the space under the master switch open and is an improvement over mounting the switch on a conduit supported from the floor. The five leads from the master switch terminate in wedge-shaped fingers which engage in corresponding receptacle terminals when the master switch and plug are placed on the receptacle. By loosening three wing nuts the plug and master switch may be removed and a spare master switch substituted.

An innovation in automatic control is being used on eight of the mill tables of a combination cross country and structural mill now nearing completion. These eight motors are controlled by eight flag master switches placed on the tables in such a position that as the steel passes through the main rolls, it will hit the flag master, thereby causing the next motor to operate. Also, as the steel leaves a given table it will release a flag master and thus stop the table. Inasmuch as this scheme is used on eight tables it will greatly reduce the number of operators that would otherwise be required.

A new design of slip regulator has been developed for steel mill service which does away with external electrode cells. A novel feature of the new design is the complete enclosure of the cells so that the possibility of leakage of the electrolyte is eliminated.

Trends in the Application of Mechanical Elements of Power Drives

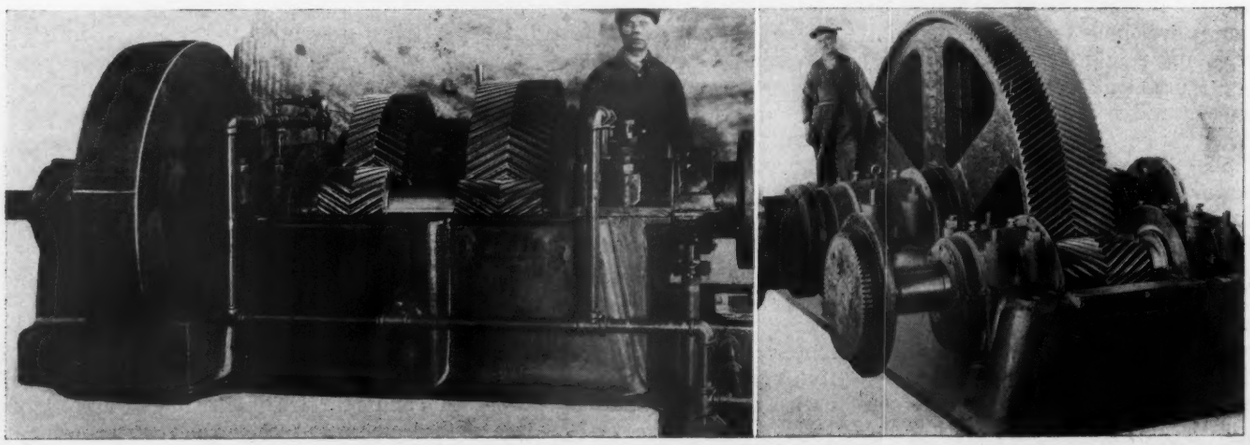
Anti-Friction Bearings—That the trend toward the universal use of anti-friction bearings is becoming very pronounced indeed, is the opinion of many steel mill engineers who were interviewed. Probably one of the largest installations ever attempted is now being made on the cranes in a new mill in the Chicago district. This company is making an installation of 20 cranes which are to be completely equipped with roller bearings. Rollway bearings are used for the motors, Hyatt roller bearings support the lineshafts, and Timken bearings are used on the axles and end trucks on these cranes. This installation of cranes will be watched with great interest, for the results secured will have a definite bearing on the universal application of anti-friction bearings to cranes.

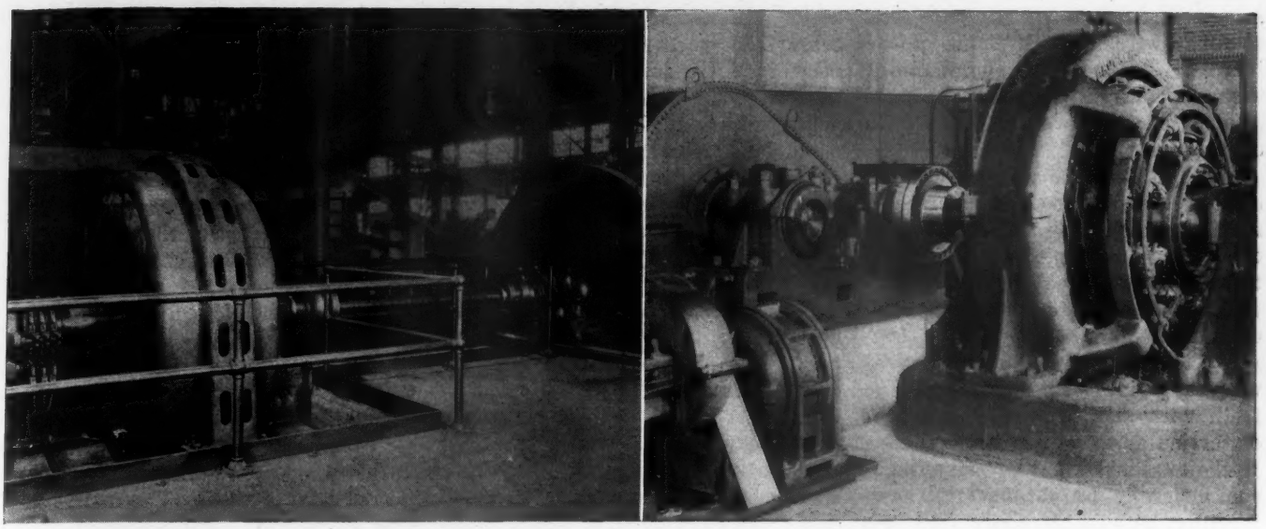
Another interesting installation of roller bearings has been made on an ore bridge recently built for the Central Furnace Co. of Massillon, Ohio. Roller bearings are used on all of the motors on this bridge, and in addition, roller bearings are used on all bearings on the trolley and hoist motions.

In the pipe mills of a large producer there are now in service approximately 300 sets of ball and roller bearings. These bearings are in use on general-purpose motors only, sleeve bearings being used on all mill-type motors. These bearings have been in service for over a year and to date not one operating failure has been experienced.

Two gear drives that are of particular interest.

On the left is shown a two-speed gear drive made by Farrell Foundry & Machine Co., that is used in connection with a bar mill of the Latrobe Electric Steel Co. permitting the use of a standard high-speed, 500-hp. motor running at constant speed. At the right is shown one of the reduction gear units made by the Farrel Foundry & Machine Co. for the new 16/20-in. strip mill of a Chicago plant. This gear will be used in connection with a 1,500-hp., 720-r.p.m. motor and has a ratio of 9 to 1. It is connected to the motor by means of a Falk-Bibby coupling.





Flexible couplings are becoming standard equipment on most types of steel mill drives.

At the left is shown a Fast flexible coupling with rigid halves and connecting shaft on a drive in the Glassport (Pa.) plant of the Pittsburgh Steel Co. On the right is illustrated a Francke flexible coupling connecting a Crocker-Wheeler adjustable-speed motor to a gear drive.

All of the auxiliary motors in a new rolling mill for handling alloy steel in the Chicago district will be equipped with roller bearings. Inasmuch as there are over 70 motors in this one mill, the installation is worthy of special mention.

Flexible Couplings—It has become almost standard practice, particularly in the more progressive plants, to use flexible couplings on all auxiliary drives such as roll tables, transfer tables, conveyor drives, hot and cold saws, fans, hoists, door machines on heating furnaces, screwdowns, manipulators and sideguards. Flexible couplings are being used to compensate for initial misalignment of shafts, wear of bearings, foundation settling, deflections of shafts, and distortion due to temperature changes and other uncontrollable conditions. One engineer interviewed favored the use of flexible couplings because in the case of gear drives, the reduction gear would be an independent unit to which the motor would be coupled by means of a flexible coupling, instead of having a motor pinion as part of the reduction gear and depending on the motor foundation bolts to keep the motor pinion in line with its gear. Still another reason advanced by a steel mill electrical engineer in the Chicago district is that the use of flexible couplings keeps the motor quite a distance away from the gears, which in turn eliminates a great deal of the trouble from oil getting into the motors; in his experience this feature was well worth the cost of the coupling.

There are several types of flexible couplings used in steel mill service and no particular type as yet seems to be preferred. One consulting engineer expressed a preference for a coupling that was capable of absorbing shocks, such as the Falk-Bibby or the Nuttall couplings. An operating engineer in the Youngstown district expressed a preference for the internal-gear type such as the Fast and Poole Engineering & Machine Co. types, while other operators are using pin types, such as the Francke, Thomas, and the like.

Flexible couplings are also used on many main drives, especially if there is a reduction gear between the main drive motor and the roll stand. A good example of this practice is in the strip mill of a Chicago plant where all except the last four stands are driven through Sykes reduction gears, which are connected to the motors by the Falk-Bibby couplings.

There have been numerous developments and improvements made in flexible couplings during the past year, especially in those designed for heavy-duty service. A special adaptation of Fast's flexible coupling has been made to fit the long tapered shaft ends of mill-type motors such as generally are used on steel mill auxiliary drives. This new design is arranged so that the coupling can be quickly disassembled and removed in the least possible time and thereby facilitate quick changes of motors in case of necessity. One hub of the coupling is made to fit the full length of the tapered shaft of the motor and is held in place by the locknut on the end of the motor shaft. The bolts on the flanges of the coupling halves are not shrouded like the standard coupling but are exposed and are fewer in number, thus being easily loosened and removed with an ordinary wrench.

Improvements have also been made in the Francke coupling. In comparison with the old Heavy Pattern Type, the improved coupling has cylindrical contact surfaces which give more than double the old contact surface; also the movement is between steel and bronze, and the graphited bushings used present a self-lubricated surface that is said to retain its lubricating qualities for many years. These new features are said to give more and easier endwise movement, increased capacity and longer life at all speeds.

The Poole Engineering & Machine Co. has also brought out a new flexible coupling. This is of the internal-gear type and it is said that it has been so designed that it is stronger than the connecting shaft and can be used on any shaft without consideration of a utility factor.

Gears—The use of heat-treated pinions is becoming almost universal mill practice and the use of heat-treated gears is increasing so rapidly that their adoption will be practically universal within the limits of the sizes that can be heat-treated. Undoubtedly, the hardness and toughness of the steel used in gears is of the greatest importance. Within certain limits the harder the material the better. There is one danger, however, which should be carefully guarded against. Some gears, after hardening, have been found to be warped excessively. This has resulted in inaccuracies in the teeth, which inaccuracies have caused more

severe stresses to be set up than could be withstood by virtue of the increased hardness and toughness of the material. In such cases the heat-treating of the gears has defeated its own object.

The specifications calling for hardened gears should always receive most careful attention. In the case of rolling mill pinions, hardened teeth are undoubtedly desirable. In the case of main drive gears, however, each installation must be considered from the standpoint of whether it is possible to harden the teeth with such a small amount of distortion as to gain real advantage. With auxiliary drives, advantages can generally be obtained by heat-treating, because the tooth velocities are generally not very high. Even in rolling mill pinions the tooth velocity should receive consideration when deciding on the method of hardening.

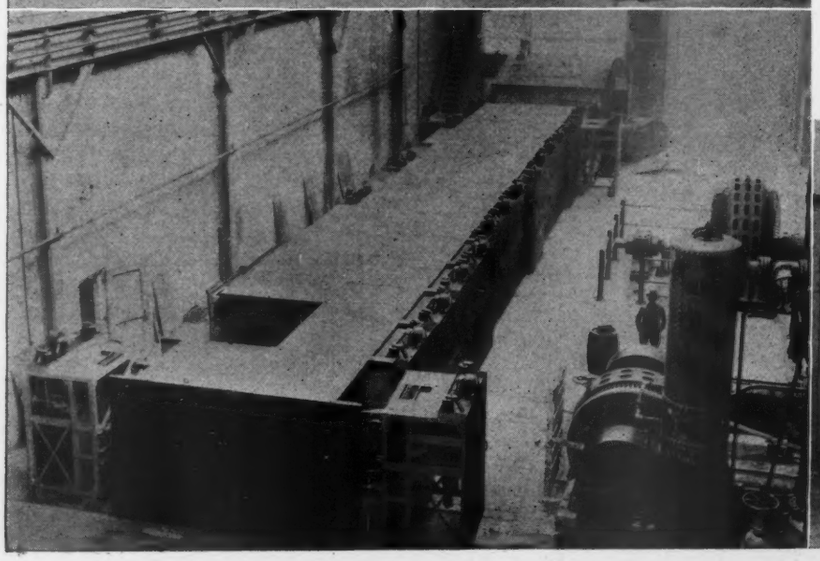
A new blooming mill soon to be erected in the Chicago district will have heat-treated pinions on all of the auxiliary and crane drives. The electrical engineer in a steel plant visited by the writer stated that all motor pinions and gears bought separate from a gear reduction unit as used in his new mill, were heat-treated. The same expression was heard from many of the other engineers interviewed.

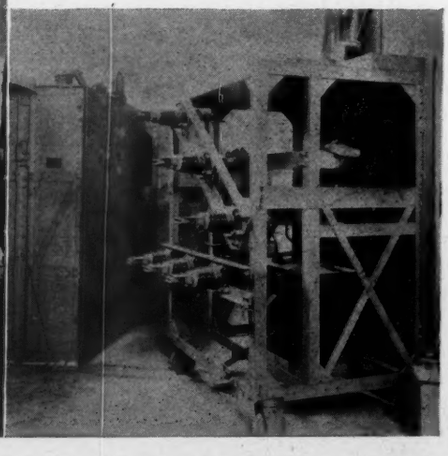
Consideration is being given to the use of single helical gears on auxiliary drives. Because of the "screw in" action of the helical tooth as compared with the straight spur tooth, its operation is considerably more quiet, reducing the noise and vibration in the gearing and correspondingly improving the action of adjacent parts of the equipment which would be affected by gearing that did not run smoothly. Spur gears give excellent results and smooth operation when running in properly maintained bearings and under reasonable supervision.

The use of single helical gearing has many advocates and also some opponents. One steel mill engineer interviewed stated that he did not favor its use on reversing drives because of the reversing end thrust. This matter of end thrust is being considered by the Standardization Committee of the Association of Iron and Steel Engineers in standardizing the mill-type motor.

For nearly all main drives requiring a motor of 150 hp. or more, herringbone gears are used for the gear reduction. Statistics made by one manufacturer of herringbone gears indicate that over 50 per cent of all the main drive reduction gears installed during 1925 were made up of herringbone gears of his manufacture. The tendency in steel mills is to apply herringbone gears having teeth with a 30-deg. helical angle.

Speed Reducers — In all of the mills visited, a large increase in the use of speed reducers was noted. Different operators offer reasons why they are using them. The main reasons given are: The self-contained reducer is more efficient, more durable, and more reliable; use of the reducer permits high-speed motors to be used and thus enables the engineer to choose the most efficient and economical motor speed while at the same time giving him the desired machine speed. Also, speed reducers have become so well standardized that they can be manufactured in comparatively large quantities and, therefore, produced at an economical price. Other reasons advanced were the small space occupied, freedom from lubrication troubles, adaptabil-





The use of truck-type switchboards is rapidly increasing.

The top illustration shows a safety, truck-type switchboard consisting of twenty-one 6,600-volt panels in the Woodlawn plant of the Jones & Laughlin Steel Corp. All equipment including the control station is located on these trucks. In the lower left-hand illustration is shown a Westinghouse truck-type switchboard in a skelp mill. This installation consists of 38 trucks arranged back-to-back to form a double-bus system. All trucks are designed for 6,600-volt service. The circuit breakers on the trucks are remote-controlled from a switchboard at the other end of the substation. The illustration at the right shows a close-up view of one of the two trucks carrying auto-transformers for starting the motor-generator sets.

ity to exceptionally dirty locations, and safety to workmen.

A two-speed gear drive for rolling mill application has been developed by the Farrel Foundry & Machine Co. and the one shown in the illustration, at left, on page 254 is used by the Latrobe Electric Steel Co. in a 10-in. bar mill. It is designed to transmit 500 hp. with a motor speed of 860 r.p.m. and to give a high speed of 275 r.p.m. to the mill and a low speed of 165 r.p.m. The desirability of a variable-speed drive for a bar mill is well understood, and it is relatively common to employ for this purpose a variable-speed motor. Such motors, with the necessary control apparatus, are expensive. The new gear drive allows the use of a standard motor, which can run at a relatively high speed. The flywheel on the pinion or motor shaft can be designed for the high speed of the motor instead of for the low speed, as is necessary when a variable-speed motor is used. This saves expense and results in better operating conditions, because the flywheel is always working at maximum speed and, therefore, it is always capable of storing or giving out the maximum amount of energy in proportion to its weight.

No one type of speed reducer is favored to exclusion. One large steel plant visited is using many of the planetary spur gear type while in the plant of a large pipe manufacturer in the Chicago district, from 500 to 600 worm gear speed reducers are in use.

Lubrication—The tendency regarding lubrication is more and more towards the complete enclosure of gears. The best practice is to mount the gears in a self-contained gear casing, which has both the pinion and wheel bearings integral. Pressure-feed lubrication is also being more widely adopted, and with excellent results. More care is taken in handling and filtering the oil. In one of the mills in the Chicago district, an elaborate Bowser oil system has been installed for purifying and supplying the oil under pressure to the reduction gear units used in the strip mill.

There is an undoubted tendency towards the use of more grease lubrication on many types of drives. On the installation of 20 roller-bearing-equipped cranes previously mentioned in this article, grease lubrication is used exclusively, the Alemite pressure system being employed.

In connection with a continuous bar mill now being erected it is interesting to note that all of the bearings on the main drive motors, reduction gears and lineshafts, as well as the motor-generator sets, will be arranged for forced-feed oil lubrication and each bearing will be equipped with a thermostat which will be connected to an annunciator. When the temperature of any bearing reaches the danger point, an alarm will be sounded and the annunciator will indicate which bearing is at fault.

Progress Made in Substation and Distribution System Design

Automatic Substations — Increasing use of automatic substations in the steel mills is one of the trends in the use of power equipment in this industry. Not only is automatic equipment applied to motor-generator sets, but also to the control of alternating-current and direct-current feeders.

So far there have been 24 equipments applied to motor-generator sets in the steel mills, controlling over 16,000 kw. capacity. The Youngstown Sheet and Tube Co. has recently purchased automatic equipment for five synchronous motor-generator sets, together with automatic equipment for d.c. feeders.

An automatic substation of especial interest was placed in service during January at the Homestead plant of the Carnegie Steel Co. This consists of two 1,500-kw., 250-volt, synchronous motor-generator sets, with provision for a future set, together with the complete automatic switching and control for these sets and for twelve 4,000-amp. feeders. This substation supplies power to the auxiliaries of the new blooming and structural mills, and is located in the main motor room which now houses two large main drive equipments, to which in the near future will be added seven more large motors for the drives. Even in this attended substation, it was deemed desirable to install automatic equipment as it was felt that the fewer delays in operation would amply pay for the higher investment.

Truck-Type Switching—The use of safety-enclosed, removable truck-type panels for controlling the main a.c. power feeder circuits in steel mills is steadily increasing. The ease of installation and low cost of maintenance, safety to operator and attendants in operation, repair and inspection, easy replacement of a unit when required either on account of a defective unit or for inspection, and the complete enclosure of all high-tension apparatus, connections and buses, are some of the principal advantages that are leading steel companies to adopt the truck-type switchboards.

One manufacturer alone has supplied 208 trucks carrying circuit breakers ranging in capacity from 300 to 2,000 amp., and in potentials from 2,300 to 12,000 volts. A large order recently placed by the Forged Steel Wheel Co. includes 41 circuit breaker trucks with steel housings and switchboard panels for the control of five synchronous motor-generator sets, two flywheel sets for main drive, reversing motors, power transformers, and several tie and feeder circuits to other substations.

An interesting installation just being finished in a mill in the Chicago district includes nine 2,300-volt trucks and four 12,000-volt trucks. These are located at one end of the substation in which are also placed the motors and motor-generator sets. No concrete cell structure is required, only the steel casing, similar to that in the illustrations at the bottom of page 256, is needed. All of the circuit breakers on these trucks are remote-controlled from the regular switchboard installation.

The largest truck-type installation that has so far been made consists of 38 circuit breakers and two auto-transformer trucks and is located in the new plant of a pipe manufacturer in the Chicago district. All of these trucks are for 6,600-volt service. The installation is illustrated at the bottom of page 256. Inspection will show that it is arranged as a double-bus system with duplicate switches on each feeder. This is for flexibility in switching. Two of the trucks have been withdrawn from their enclosures so as to show the circuit breakers. These breakers are remote-controlled from a switchboard at the other end of the room.

A recent development in switching that will interest many steel mill operators is the announcement that the Allis-Chalmers Manufacturing Co. has secured the exclusive right to manufacture the Reyrolle Armorclad Switchgear. This switchgear, like the truck-type switchboards, eliminates all cell structure for the isolation of busbars, transformers, disconnects, etc. The switch-house resolves itself into a simple shelter for the switchgear. All conductors,

including the busbars, are enclosed within grounded metal coverings. These coverings are such as to prevent the throwing out of flame, or hot gases, or the escape of gases in quantities and at points where mixture with the surrounding air might result in explosion.

Power Factor—Power factor continues to worry some steel mill operating men, especially those who purchase power. One plant having poor power factor has just completed a tandem strip mill using the Ward-Leonard system with adjustable-speed motors. This plant expects to improve its power factor by the additional load obtained from the synchronous motor-generator sets supplying the adjustable-speed motors.

A large independent mill in the Chicago district that purchases practically all of its power, has a power factor between 90 and 92 per cent lag, because of the five over-excited motor-generator sets that it has in operation.

During the past year a static condenser installation of 480 kva., 2,300 volts, has been made in the Western Reserve plant of the Youngstown Sheet and Tube Co. We are advised that the installation has practically paid for itself in 6 mos.' operation by the reduction in purchased power bills, and that the operators are very much pleased and enthusiastic over the success of this equipment.

Distribution — The distribution system used by a large pipe manufacturer in the Chicago district offers many features of interest as well as methods of saving on the initial investment required. At this plant there are three voltages that are carried through the mill buildings for supplying the auxiliary drives and the lighting circuits. These are 250 volts d.c., 220 volts, three phase a.c., and 110 volts, single phase, a.c. The various mill buildings in this plant are arranged in two groups, one group containing the skelp mill buildings which are arranged side by side and the other group containing the pipe mill buildings. The pipe mill buildings are arranged adjacent and parallel to each other, with a long aisle extending crosswise through the center of all of the buildings. The substation for the pipe mill buildings and likewise the substation for the skelp mill buildings is located at a central point in each group of buildings and adjacent to the aisle extending crosswise through the buildings. Instead of running cables from the switchboards in the substation to the various mill buildings, the following scheme was adopted:

Busbars are used to carry the 250-volt d.c. and 220-volt a.c. power from the switchboard in the substation through the basement to the central aisle and up the wall of the central aisle to a point just even with the eaves of the building. These buses are arranged vertically one over the other, each bus being supported by a horizontal busbar support and braced on top and below by a busbar insulated spacer. This method of mounting holds the buses together rigidly; also, the use of the busbars provides the heavy carrying capacity required. At the eaves of the building, at the end of the busbars, rubber-insulated cables are connected and are carried both ways along the central aisle to the various mill buildings. These cables are carried on porcelain insulators and fastened to the roof trusses. As the cables are above the crane runway, it is impossible for anything to come in contact with them.

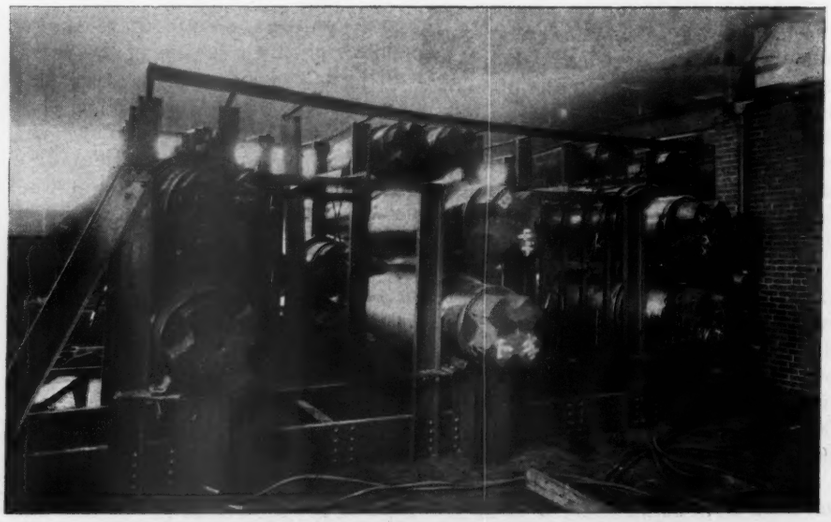
This open construction was favored, first, because it was a less expensive form of construction; second, the cables are protected for they are up near the roof where nothing could strike them; third, it provides the most flexible arrangement for making taps to any desired point in the building; and fourth, it is accessible for repairs or alterations. Taps for these cables are run to balconies placed in each mill building in which are located a distribution switchboard and a transformer for transforming 220 to 110 volts for lighting. From the distribution panels, cables are again carried up to the roof trusses and through the length of the particular mill building in which the control balcony is located, from which taps to the various individual machines are made. These tap circuits are carried in conduits from a point level with the eaves of the building to the particular machine which is to be driven. Also, all circuits coming from the main feeder cable to the distribution panel in the balcony and back up to the individual mill circuits, are carried in conduit. In other words, conduit was used for all wiring below the level of the building eaves.

Each individual drive motor has a totally-enclosed circuit breaker located near it, thereby providing adequate protection to the feeders at the motor ends.

An interesting method of installing and wiring the general lighting in the mill buildings of this plant is used. Messenger cables were strung lengthwise on each side of the roof of the building and the lamps are suspended from the messengers. This allows the use of whatever spacing between them is desired. These messengers are hung from the roof trusses and hold the lamps above the cranes that pass beneath. The flexibility of the messenger wires provides whatever shock absorption might be necessary. The wiring for the lamps is carried

Spare sheet mill rolls are kept hot for emergency use.

The spare rolls are kept in the rack as shown. An electric roll heater is clamped around each pair of rolls as shown at each end of the rack. Power is kept on the heater continuously so as to keep the rolls ready for immeimmediate use. This installation is in the plant of the International Nickel Co., Huntington, W. Va.



in open work on the roof trusses which makes the wiring very simple indeed. Access to the lamps for cleaning is obtained by standing on the bridge walkway of the cranes.

Improvements Made in Yard Transportation Systems

Ever since railroads have been used in steel mill yards as the backbone of the mill transportation system, the steam locomotive has been the accepted form of motive power. However, its wastefulness for switching service has long been recognized and many schemes have been used to overcome this wastefulness and high maintenance cost.

Many operators are showing considerable interest in yard electrification and some progress has been made. The Edgar Thompson Works of the Carnegie Steel Co. has recently purchased an 80-ton electric locomotive for moving hot metal from the blast furnaces to the mixer and steel plant. Power at 250 volts, d.c. is supplied by a double, third-rail system. Collectors are mounted at each of the four corners of the locomotive so that one or more will always be in contact with the third rails when passing over crossings, switches, and the like.

The Duquesne plant of the Carnegie Steel Co. is putting into service a 25-ton, storage-battery locomotive which is to be used by the Electrical Department in transferring motor armatures and other apparatus requiring shop repairs, to and from the electrical repair shop. Four storage-battery locomotives are used on the narrow gage railroad system in the plant of a large pipe manufacturer whose mill is located in the Chicago district.

Considerable interest has been expressed in the possibilities of the new oil-electric locomotives for industrial and steel plant switching service. Briefly, in these locomotives an internal-combustion oil engine, using low-grade fuel oil, drives an electric generator which furnishes power to electric motors geared to the axles of the driving wheels. The advantages are much more economical and speedier operation, and absence of noise and smoke. These locomotives are a joint development of the American Locomotive Co., Ingersoll-Rand Co., and General Electric Co.

In comparing steam and oil-electric locomotives for industrial and steel plant service, it is said that industrial plants are not generally equipped with shops and facilities for the convenient and economical repair of locomotives. In consequence, the maintenance of steam locomotives is higher than would be the cost of the same locomotives on steam railroads. In industrial plants the switching service is frequently intermittent, even more so than in large steam railway terminals. In all cases of intermittent service, it is a fact that the steam locomotive is using fuel during all of the period when the steam pressure is kept up. On the other hand, the oil-engine locomotive uses fuel only during the period when it is exerting power, and only in proportion to the power used. As a consequence, the more intermittent the service, the greater is the advantage of using an internal-combustion type of engine in the power plant.

Tendencies in Use of Electric Heat in Steel Mills

Developments in the use of electric heat in the steel industry are not at a standstill. On the contrary new applications and refinements in former applications are constantly being made.

Early last year there was installed at the plant of the International Nickel Co., Huntington, West Virginia, equipment for heating the tops of ingots, primarily Monel metal and nickel. Before using this equipment, 3,800 lb. of metal were poured to obtain a 3,000-lb. ingot, the waste averaging 20 to 30 per cent. Now 3,250 lb. of metal are poured and 85 per cent of the ingots are used with very little cropping, while a large proportion of the remaining 15 per cent is worked into commercial products.

Previous to the use of this method, it was necessary to cast the ingot with a head 18 in. long and weighing approximately 800 lb., the purpose of which was to take care of gas holes and pipes. Of course, it was necessary to saw off the head and return it to the furnace for melting. By the new method an electric arc applied to the top of the ingot keeps the metal at the top hot while the bottom and sides are cooling. The hot metal at the top is thus available to fill up any holes caused by shrinkage. Considerable success has attended the use of this method on Monel metal and nickel ingots and it may have possibilities on ferrous metal ingots.

Roll Heaters—The use of electric roll heaters in sheet mills is showing a large increase. Since September 1, 1925, 45 equipments have been sold. An interesting installation has been made at the Monel metal sheet mill of the International Nickel Co. With the methods of heating the rolls formerly used, it was necessary to roll steel sheets for more than one turn so as to get the mill warmed up and in proper condition to start rolling Monel sheets. This was required because Monel metal is too expensive a material to waste in getting the mill into condition for operation. It was, therefore, necessary to purchase steel bars and manufacture second-grade sheets in conditioning the mill. By using the roll heaters it is necessary to roll only two or three steel bars before going into production on the Monel metal sheets. The resultant saving is, therefore, considerable.

Some mills have fitted up racks to hold spare rolls in such a manner that a roll heater may be used to keep them hot and ready for immediate use in case it should be necessary to replace a set of rolls on account of breakage or wear. Such an installation is shown at the bottom of page 258.

Arc Furnaces—Installation is now being made of the first three-voltage control of arc melting furnaces. These equipments are to be used on 6-ton, three-electrode furnaces.

Each equipment consists of a 2,550-kva. bank of transformers which will deliver full output at 165, 156 or 147 volts and at lower capacity at 138, 120, 95, 90, 85, 80 or 70 volts. In operation the melter will have a choice of several voltages to start the heating, probably using 2,550 kva. at 165 or 156 volts, 2,400 kva. at 138 volts for the intermediate voltage and a still lower kva. at the refining voltage, probably 85 or 90 volts, depending upon the furnace requirements.

By using this equipment it is expected that considerable economies will be effected in furnace operation, especially from the standpoint of the life of the side walls and roof, together with possible reduction in electrode consumption.

In addition to these three equipments which were installed by the Halcomb Steel Co., four other equipments of this type have been sold, and it is expected that three-voltage operation will become the accepted method of operating arc furnaces taking 2,000 kva. and above.

This 15-ton crane is completely equipped with roller bearings.
It is one of a total of 32 cranes so equipped. Inspection will show the character of housings used to enclose the roller bearings on the lineshaft, motors, and hoist countershafts. Note the method of locking and enclosing the roller bearings on the trolley axles. All of these bearings are lubricated with grease and are filled through pressure fittings such as shown on the top of the bridge motor bearing in the left foreground.

Operating results obtained by use of

Anti-Friction Bearings on Steel Mill Motors

together with a discussion of the various factors that were considered in applying them to all bearings on thirty-two traveling cranes

By A. G. PLACE
Electrical Engineer, Youngstown Sheet & Tube Company, Youngstown, Ohio

IN THE manufacture of rolled steel products from iron ore, the product is never touched by human hands until it nears the finished stage. Throughout the manufacturing process it is handled entirely by machines which are universally driven by electric motors. These motors have to run 24 hr. per day, and delays on them must be eliminated. In our experience, the most valuable and interesting step in eliminating these delays has resulted from the use of roller bearings in these motors.

Early in 1918, our first successful roller bearing installation was made in the East Youngstown plant of the Youngstown Sheet & Tube Company by L. J. Hess, at the time chief electrician of the East Youngstown plant, and consisted of two sets of roller bearings in two mill-type motors on the bridge motion of a hot metal crane in a mixer building of a Bessemer plant. This is one of the worst locations in the mill for electrical equipment, because when hot iron from the blast furnaces is poured into the mixers, flakes of graphite and iron float in the air and cover everything in the building. These flakes are abrasive and also conduct electricity so that they are a prolific source of trouble.

The main reason for trying out these bearings was the possibility that roller bearings might eliminate bearing wear, bearing failures, and electrical failures due to oil penetrating the mica on the commutator and to oil on the windings. This trial installation was a marked success. Previously on this drive a 4-mos. run on babbitt bearings was considered to be very good, while frequent armature changes, broken bands, and flat spots on the commutator were the rule. When the roller bearings were installed, the armature was in poor shape and had an estimated life of 3 mos. if babbitt bearings were used. It ran on roller bearings for 9 mos. and after the armature was rewound and a new commutator installed, the motor has

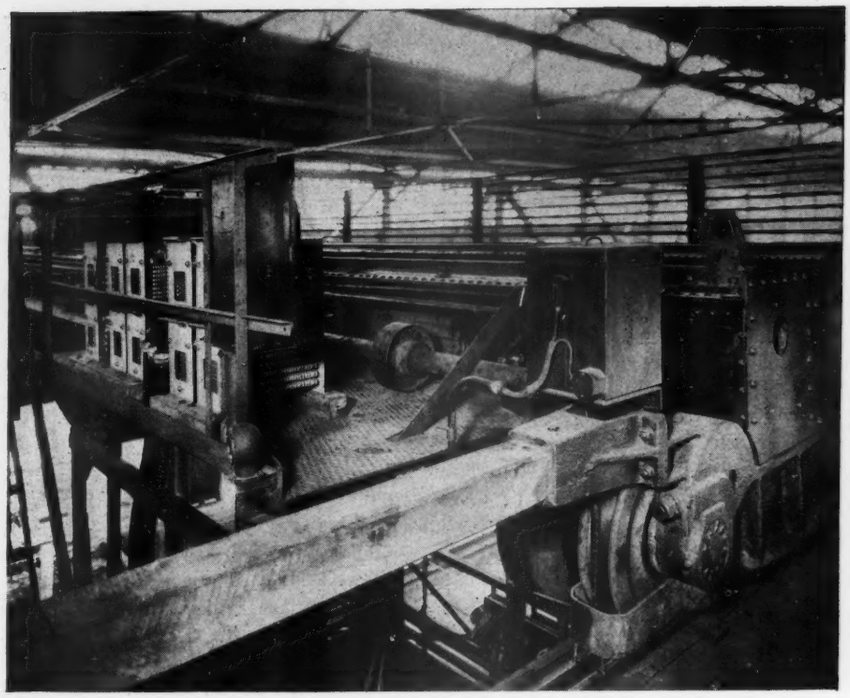
run since then without further trouble.

Excellent Results Obtained from Trial Installation

The excellent results obtained from this trial installation led to applications of roller bearings in other locations, such as reversing tables handling heavy ingots in the blooming mills, soaking pit cranes, screw-downs, and other locations where motors were hard to maintain. These first bearings were all applied to mill-type motors running at slow speeds, from 450 to 900 r.p.m., most of them having a pinion mounted on the armature shaft as shown in the illustration on page 262, although some drives were direct-connected.

The results obtained were exceptionally good. Oil was no longer deposited on the commutator and failures of the mica V-rings and segments decreased to a minimum. Failures due to oil-soaked windings were eliminated. With the armature always running in the center and with no low bearings, the field flux and air gap were uniform around the armature circumference. No trouble was experienced from grounds burning the roller bearings. It was no longer necessary to use "feelers" every Friday to determine what low bearings should be changed on Sunday.

The results obtained from the use of these roller bearings showed conclusively that maintenance costs can be substantially reduced, and consequently we have put large numbers of anti-friction bearings in service.



Roller bearings are used in the axle bearings of the bridge.

The illustration shows the method of enclosing the roller bearings. The fitting for grease lubrication can also be seen on the side of the housing. Note the use of the electro-magnetic sander, shown in the right foreground, and also the crane warning lights in the left foreground. These warning lights are placed at the four corners of the crane.

The first bearings were equipped with thrust plates, so that the end thrust would bear against rollers set in the plates, and all the shafts were heat treated. After the bearings had been in service for some little time, it was found that the thrust plates were not needed to take care of end thrust and hence they were omitted. Also, it was found that heat-treated shafts were unnecessary, and these have been abandoned.

Roller Bearing Installation Done Only in Shop

In order to make sure that the bearings would go into immediate service without any trouble, all installation work is done in the shop and each motor is given a 3-hr. test run at high speed before it leaves the shop. It has been found desirable to give the armatures sufficient

The lineshaft driving the bridge track wheels is also equipped with roller bearings.

This 15-ton crane is in the hot mill building of a sheet mill. It will be subjected to the usual severe steel mill service.

end play and accordingly the side clearances have been increased. Only one kind of grease is used in all roller bearings and care is taken not to fill the bearing too full of grease. A bearing about one-third full will run cool, but a full bearing will heat up. In determining the sizes of bearings that should be employed on a given application, we have used a large enough factor of safety with the result that no failures have occurred from using sizes too light for the duty required. The bearings used have consequently given satisfactory service.

The satisfactory results obtained have proved that inspection labor can be cut down materially in addition to the savings resulting from the following items:

(1) Reduced number of rewinds caused by oil-soaked armatures.

(2) Reduced lubricating expense.

(3) Reduced repair and shop labor on bearing renewals.

(4) Less oil and grease on rolled products.

(5) Less power consumption.

(6) Reduced inventory of spare commutators and coils.

After calculating the above savings, it was determined that a substantial return exists on the investment cost required to equip all new motors with roller bearings. This added investment cost is approximately ten per cent extra per motor. Accordingly, practically all new motors have been purchased with roller bearings.

Roller bearings have been used in our plants in other application than on electric motors. Ingot cars and coal mine cars have been so equipped for several years. As a result of the service obtained, the management decided to equip completely 32 electric overhead traveling cranes with roller bearings throughout. The illustration on page 261 shows the general type of cranes on which the roller bearings are installed.

In applying these bearings, a great deal of attention in co-operation with the crane builders was paid to the following details:

The bearings on the trolley side frames are enclosed in housings and the housings in turn have a spherical seat in the trolley frame casting, in order to prevent strain on the bearings when the trolley loosens up after continued service. This may not prove necessary but was adopted after tests and observations on present heavy-duty crane trolleys. End thrust on the bearings was allowed for in all cases.

The roller bearing diameter on the bridge lineshafts had to be in English inches instead of in the metric dimensions of the recently adopted standard for roller bearings, in order to permit the use of cold-rolled shafting on the long lineshafting, which is made up in diameters based on the English system of measurement.

The back or axle shaft bearings on the motors are equipped with roller bearings, each incased in a housing which is carried mounted on the shaft. These housings are advisable in order to keep the dirt and steel dust out of the bearings in case a shaft has to be changed. A spare shaft can be carried with the housings and bearings already mounted.

The sheaves on the hook blocks are equipped with roller bearings on some cranes, but not on all. The large pin diameters on blocks of over 15 tons capacity make it necessary to use such large diameter roller bearings that the cost runs up beyond the economical point on these particular bearings.

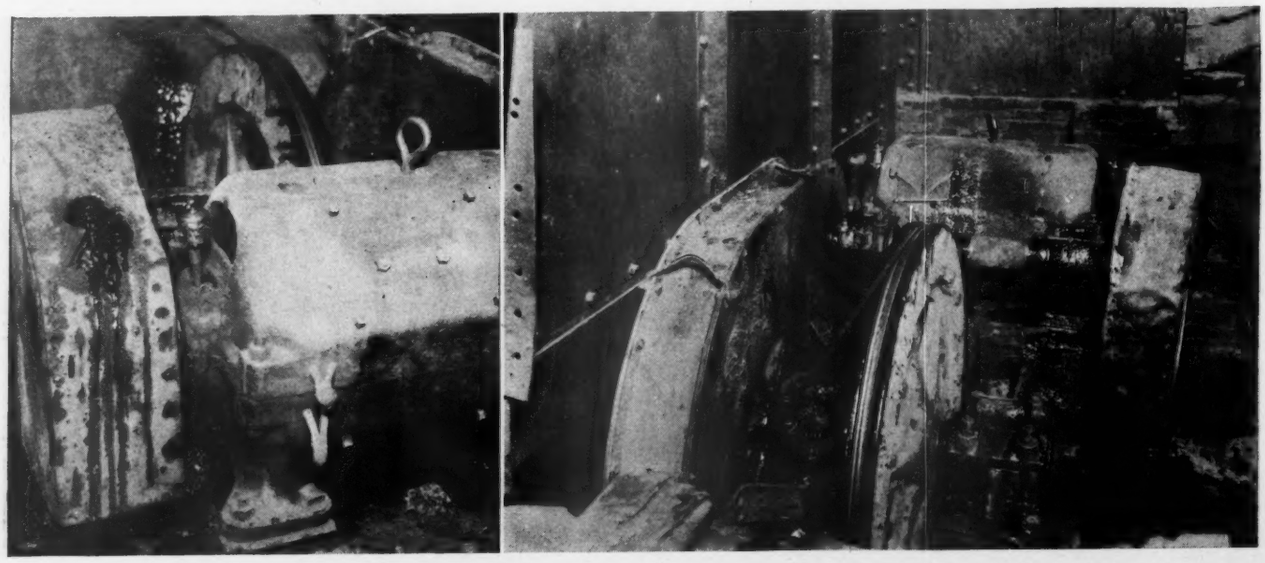
Most of the cranes have just been erected and started up, hence it is too soon to make any statement regarding the operating results.

There are other applications in steel mills where it may be possible to secure savings by using roller bearings and several such applications are now being investigated. In applying roller bearings to any steel mill work there are two important factors that must be given considerations: (1) Whether or not it is possible to make a saving sufficient to justify the extra investment required; and (2) whether or not the machinery can be designed with roller bearings and be absolutely correct in design so that it can be depended on for continuous operation.

In general, it may be said that we have found anti-friction bearings on electric motors to be a remarkably good investment. It is not at all surprising that this is the case, when it is considered that motors are very expensive, and that for 10 per cent additional cost they can be insured against failures which require expensive repairs.

The motor shown in this application has roller bearings on its armature shaft.

The illustration at the right gives some idea of the service conditions under which the motor operates. The drive is located in a pit at one end of the blooming mill soaking pits. The motor drives a sheave wheel through two gear reductions, which pulls a cable that draws an ingot buggy carrying ingots from the soaking pits to the mill approach table. The drive is subjected to plugging and sometimes to "inching" the buggy for spotting.



When not required outside the arc welder unit is kept near the curtained enclosure.

This is a portable, 300-amp. Lincoln arc welder. It is plugged into the receptacle on the wall through a 150-ft. Tirex extra-heavy rubber cord. The 150-ft. cord is long enough so that welding may be done almost anywhere in the shop without moving the machine. The welding bench and cabinet are shown in the background. The preheating furnace is connected up with gas and air lines and is used for all castings which must be preheated before welding. The large cast sheave wheel at the right belongs to a clamshell bucket, and was brought to the shop to have the broken sheave welded.

Some applications of

Arc Welding in Plant Maintenance Work

including the procedure followed and the savings in time and money that have resulted from the use of this process in repair and new construction work

By F. A. HAGEDORN
Assistant General Superintendent, Coke Ovens, South Chicago Plant, By-Products Coke Corp., Chicago, Ill.

WHEN we added an electric arc welding unit to the equipment of the Maintenance Department some doubt existed as to whether there would be enough work to keep it busy and make it earn on the investment. Now we are wondering how we ever got along without it.

The South Chicago plant of the By-Products Coke Corporation covers 110 acres, contains 330 ovens, a coal unloading dock, several miles of conveyor systems, a power plant, and numerous tanks, pipe lines, and other equipment necessary in the processes we employ. The manufacture of coke and gas is a continuous process and the plant does not stop even for holidays.

Because continuous operation is of such prime importance it is essential that we maintain every possible facility for making the repairs or alterations necessary to keep the plant going. On the other hand, the hot gases and liquors, as well as the abrasive coal and coke dust, are most destructive to the plant equipment. This necessitates a large amount of renewal of broken and worn parts of the equipment or structure. We are using our acetylene and arc welding units together on this work, and every day are finding new uses for them. At present, whenever a large or small repair or construction job becomes necessary, practically the first consideration is to see whether a welding or cutting set can be used in the work.

The acetylene outfit had been in the plant for several years before we installed the arc welder. At present we have 11 Oxweld (Oxweld Acetylene Company, New York, N. Y.) sets for maintenance work. All sets are portable and consist of an oxygen and an acetylene cylinder mounted on a hand truck with a torch and gas and air hose. These sets are

Three other examples of construction work made in the shop.

The sections of pipe on the bench are to be part of a return bend. The bent angle-iron frames on the bench are used to bolt the sections together while arc-welding. These sections were cut out of old pipe with the torch. The shop horse and the portable forge are other examples of arc-welding jobs.

taken anywhere in the plant as necessary.

The arc welder is a 300-amp., type FKW-FKW Lincoln (Lincoln Electric Company, Cleveland, Ohio) portable, motor-generator set. Receptacles are located at many places around the plant to tap this outfit into the 250-volt, direct-current distribution system. Frequently it is necessary to take the set outdoors. One of the first things we did was to build a steel housing over the set to protect it from the weather. On one of our first big welding repair jobs the arc welder remained outside for three or four weeks.

All connections to the arc welder are made with Tirex (Simplex Wire & Cable Company, Boston, Mass.) heavy rubber portable cord. There are 150 ft. of this cord connecting the welder to the electrode holder, 75 ft. to the ground, and 50 ft. from the receptacle to the machine.

Our basis of dividing the work between the arc and acetylene outfits may be interesting to others. Cast iron and all jobs which require preheating are welded with an acetylene outfit; also, a considerable amount of cutting is done, as will be described later. In addition, many of the smaller welding jobs which cannot easily be brought into the shop are acetylene-welded because the portable gas units are smaller and more easily moved.

Practically all steel welding, except the small jobs which are done around the plant without dismantling the equipment, is performed by the arc unit. In some cases both gas and electric outfits are used.

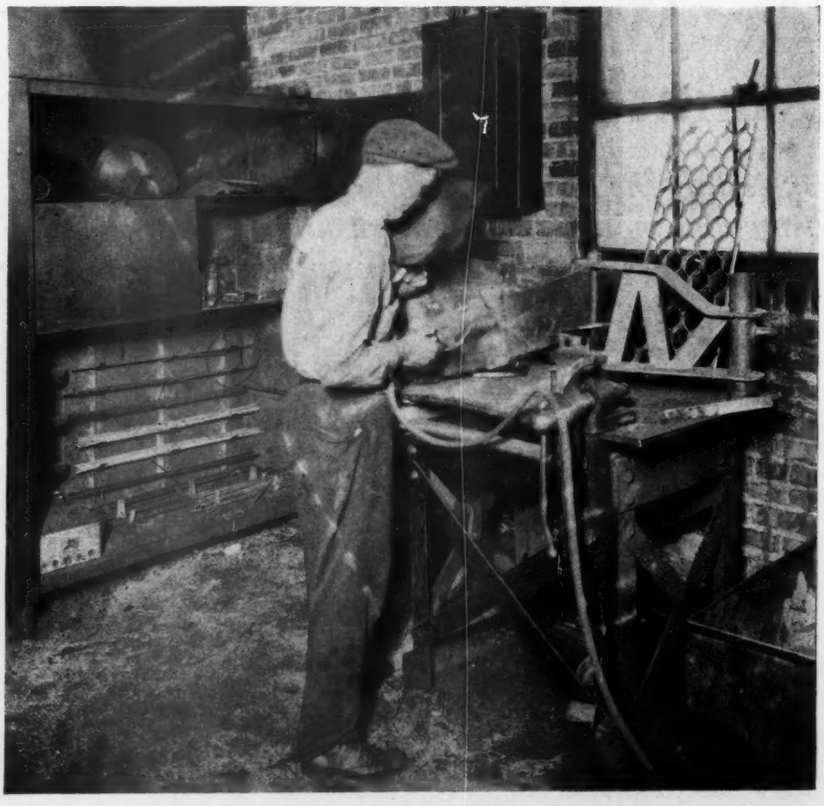
We have one experienced man capable of performing any necessary welding with either the gas or arc units, and another who is breaking in and can do many of the simpler jobs.

In all of our welding or repair work we keep two primary considerations in mind: the welds must be substantial and the work must interfere as little as possible with the continuous operation of the plant. Appearance of the weld is not in our case so important as it is in some other industries; however, the welder takes enough pride to do neat work. Also, we do not sacrifice reliability to save a little in time or material.

Two large welding jobs stand out above the others so prominently because of their size and importance that they deserve first mention. One of these consisted of about 400 ft. of heavy welding on a gas collector main, and the other was the construction of a large seal.

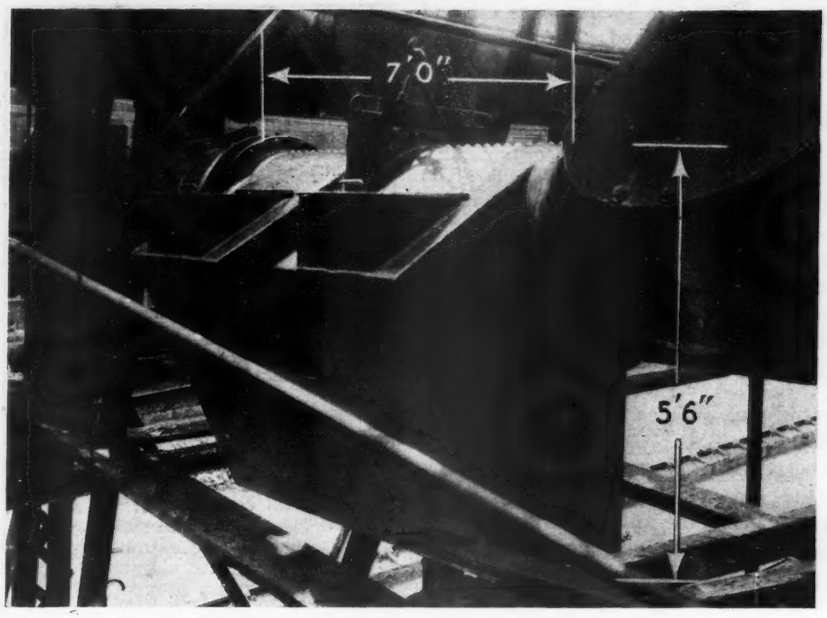
The hot gas and liquors in the gas collector main, which extends across the top of each battery of 40 ovens, corrode the baffle plates which dip down into the liquor and make a seal. These plates have to be renewed periodically. The former method consisted in stopping coke-making on the entire battery of 40 ovens, and then cutting out the old rivets and riveting in a new plate. This work was pushed as rapidly as possible, but usually required about 10 days. The loss of 10 days' production every five or six years is a big item of expense and amounted to more than the cost of the repair.

Shortly after installing the arc welder we conceived the idea of replacing the baffle plate by welding, and without stopping the operation of the ovens. How this was done is best shown by reference to the illustration on page 265. The row of rivets just above the arrow indicates the previous method of fastening the baffle plate which can be seen through the open inspection door. The metal doors and the framework covering the trough were corroded so badly that they had to be replaced



This shows the welding bench and cabinet, with examples of work done.

This bench and supply cabinet are enclosed with a heavy canvas curtain. The welder has just finished building up a large gear guard by welding steel plates together. The floor grating leaning against the window was arc-welded together by one man in less than half the time that would be required by two men to rivet it. The other piece on the bench is a special replacement part.



This large seal is a good example of the type of work on which welding may be used.

This seal is made from two pieces of 30-in. heavy riveted pipe, four flanges cut out of 1-in. plate and welded on, and a box welded from ⅜-in. plate. On the inside of each end of the seal, pieces of 12-in. pipe are welded onto the lower side of the 30-in. pipe and extend down almost to the bottom of the seal. A steel plate between the flanges closes the 30-in. pipe in the center to prevent gas passing. The liquors are forced down into one side of the seal, up the other side, and withdrawn. The flanges and pipe were all cut with the acetylene torch and arc-welded together.

also. New covers were made up, the old metal cut out, and the new parts welded in position. The weld is indicated by the heavy deposit of metal which serves as a fillet to bind the new cover plate to the gas collector main. The old baffle plate was then cut off and the new one bolted on, as shown by the row of bolts just below the arrow, in the illustration below.

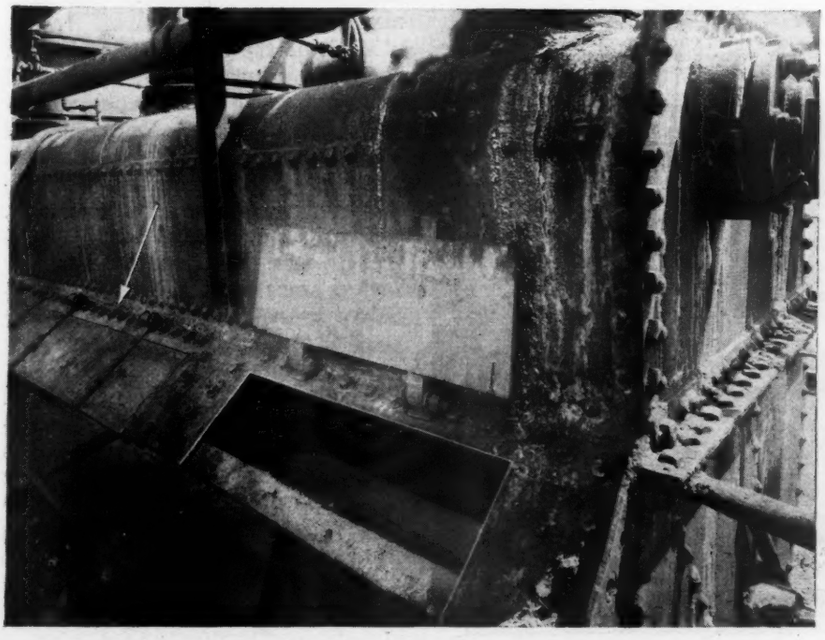
This work was done in sections and required between three and four weeks. However, the battery of ovens was in continuous operation all the time. The gas in this collector main is under very low pressure. While the work was carried on a man was stationed at a regulating valve to keep the pressure as low as possible. Pails of sand were kept within reach to smother out the few fires that were started by the welding or cutting units.

This repair was made a year ago and is standing up very well. A big advantage, in addition to not having to stop the operation of the ovens, is that the next time the baffle plates have to be changed it can be done by taking out the row of bolts and fastening on a new plate. If any part of the wall corrodes, either the surface can be built up or another piece of metal may be tack-welded down over it. In our opinion the new arrangement is much better than the old. The comparative costs of labor and material in making this repair in the old and new ways are in the ratio of about 4 to 1. This comparison does not take into account the big advantage of being able to operate the ovens while making the repair.

The gas collector main on a second battery of 40 ovens was welded in a similar manner shortly afterward. These two jobs totaled about 400 ft.

The other large welding job was performed on the seal box shown in the illustration on this page. This has just been completed and placed in position. This box was made up completely by cutting and welding and had to be of exact length to fit into the section of the line which it replaced.

This seal consists of two pieces of 30-in. steel pipe each about 42 in. long. These were cut to length with the torch. The four flanges were cut from 1-in. steel plate with the torch and arc-welded on. The alignment of the bolt holes had to be perfect. A piece of sheet steel fits in between the center pair of flanges and prevents the passage of the gas. The liquors enter from one end and pass down into the seal through a 12-in. opening and pipe extending down into the seal, and on out through a similar opening and pipe extension in the other end of the



This and a companion job required 400 ft. of arc welding.

This is the seal on the gas collector main; it is mounted above and extends the entire length of a battery of 40 ovens, a distance of about 200 ft. Formerly it was necessary every five or six years to stop coke-making for about 10 days to replace the corroded baffle plates, which extend several inches down into the liquors. The baffle, which may be seen through the open door, was formerly riveted on; the longitudinal row of rivets holding this is shown beside the arrow. About a year ago entire new covers and doors to the seal were welded on at the seam indicated by the arrow. The new baffle plates are bolted onto this cover as indicated by the row of bolts and can be replaced or tightened up at any time. Four or five men did the necessary welding, without interfering with the operation of the ovens, and at one-sixth the former cost for labor and material.

seal. Thus the liquors pass on and the gas is retained. This box part of the seal was made up from steel plates arc-welded together. The straight edges of the ⅜-in. steel plate forming the box were sheared true. The curved saddle fitting onto the 30-in. pipe was cut out with the torch. The plates in the seal were welded up in the shop in two days. The cutting and welding of the pipe sections took longer.

The cost was considerably lower, I believe, than would have been the case with any other way of making this seal. We expect to make others as necessary. Corroded plates may be repaired by building up metal on the outside or by tack-welding a plate over the thin metal.

Arc welding requires clean metal and a clean surface, neither of which are provided for in most of the necessary repairs around a coke plant. Frequently we use the acetylene torch to clean up the metal, and then weld on a patch with the arc.

Another large job which represented not only a considerable saving in money but, what was more important, reduced the time out of service from several weeks to a few days, was the welding of the manganese-steel bowl shoe or biter strap on a 6-ton clamshell coal bucket. This was broken in several places and a new shoe would have cost about $500, while several weeks would have been required for delivery. Upon hearing this from the manufacturer we decided to try arc welding. Manganese-steel welding rods were used and the bucket was soon back in service. Estimating $15 or $20, which are ample figures, as the cost of the welding, the saving on this job totaled $480 or more. The cost of the freight on a new shoe and the loss caused by the bucket being out of service for the several weeks would probably have amounted to as much more.

While these three jobs may be considered as the high lights of our experience in welding they actually represent only a small part of the work. Much of the welding consists of miscellaneous little jobs some of which represent repair or broken parts; others are new construction.

It is, of course, almost impossible to list the welding jobs handled in any given time. A few representative jobs, however, are of interest.

Most of the motors in the plant are connected up through gear drives. The heavy shock loads, such as starting conveyors and other heavy equipment, loosen up the keyways in the shaft. In such cases, the old, worn keyway is filled in by arc welding, the ridge of surplus metal turned down in a lathe, and a new keyway cut in the shaft. This makes it practically as good as new and the operation may be repeated whenever necessary. During the course of a year we salvage a number of motor shafts by welding in this way.

Also, we frequently find it necessary to build up the diameter of a shaft by arc welding. In another case a 30-in. cast-steel gear with a 5-in. face was salvaged by arc welding in a few new teeth. A new gear would have cost $100 or more.

We use a considerable amount of steel floor grating. As changes are made in the plant gratings of special sizes or shapes are required. To get these quickly, we purchase the steel straps already bent and punched and formerly had been riveting or bolting these together as necessary. Now the bent straps are assembled and clamped together in position and arc-welded on both sides. Welding requires less than half the time formerly taken by two men to rivet or bolt the strap together. One man alone can weld them.

Much of the new structural work about the plant is being arc-welded as it is quicker and cheaper, we believe, than riveting. Practically all old structural work is cut out with a torch. So far, however, we have not tried welding up any pipe lines.

Due to the abrasive action of the coal or coke dust the steel conveyor pulleys wear rapidly. These are repaired in the shop by bending a new steel plate around them and welding up the seam and ends.

Another job of considerable size consisted in cutting the feed pipes between the bunkers and the stokers in our power plant and rewelding them at a different angle. The cutting and trimming were done with the gas torch and the welding by the electric arc.

(Please turn to page 271)

Quantities of Electrodes Used Monthly

100 lb. ⅛-in. Arc Carbox
50 lb. 5/32-in. Arc Carbox
50 lb. 3/16-in. Arc Carbox
(Central Steel & Wire Co., Chicago, Ill.)

25 lb. 3/16-in. iron rod
50 lb. ¼-in. iron rod
10 lb. ⅜-in. iron rod
10 lb. ⅛-in. steel rod
10 lb. ¼-in. cast-iron rod
(Oxweld-Actylene Co., New York, N. Y.)

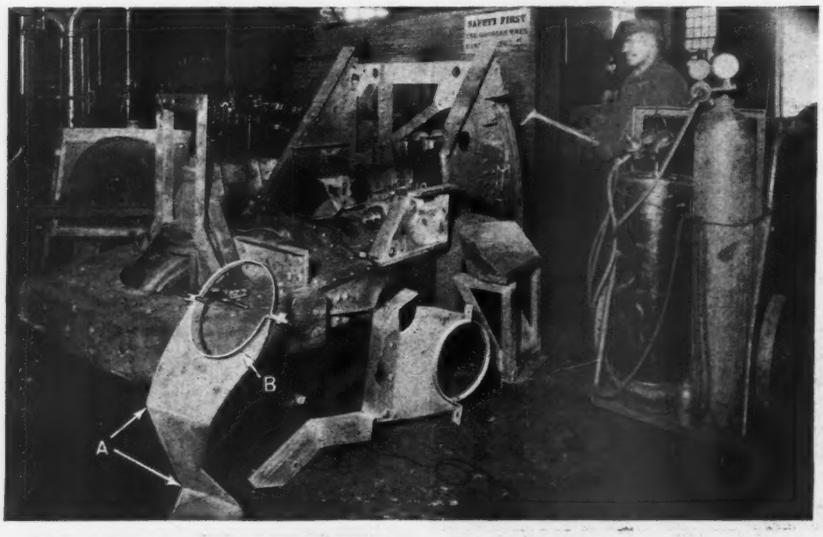
10 lb. E-Z Welding Compound
(Anti-Borax Compound Co., Fort Wayne, Ind.)

Miscellaneous Supplies Used in Small Quantities

⅛-in. Nickel steel
3/16-in. Nickel steel
¼-in. Nickel steel
¼-in. Manganese steel
3/16-in. Lynite aluminum
¼-in. Lynite aluminum
⅛-in. Tobin bronze

Both gas and electric units are often used on a repair job.

A large proportion of the metal cutting is done with the gas torch. Most of the steel is welded with the arc. This illustration shows one of the portable gas sets. This special gasoline industrial truck is being rebuilt, largely by cutting it apart with the torch and then welding in new parts. The bends indicated at *A* were made by cutting a slot through the metal (except for about ⅛ in. at each edge) where the bend was to be made. After making the bend cold the slot was filled in with the arc. The collar *B* was made from a curved steel strap, arc-welded on. The other pieces on the floor were also cut to shape with the torch and arc-welded.



Operating Characteristics of Crossed-Belt Drives

as determined by a series of tests, with particular reference to the minimum center distances which can be used in laying out such drives

By R. F. JONES

Research Engineer, The Leather Belting Exchange Foundation, Cornell University, Ithaca, N. Y.

IN THE study of the characteristics of belt drives under various operating conditions, The Leather Belting Exchange Foundation has been conducting tests on leather belts under different services. Previous tests have been made and reported on horizontal belt drives to determine the effect of diameter and ratio of pulleys, center distance, high belt speed and the use of the gravity idler. The results obtained were published* in the June, 1925, issue of INDUSTRIAL ENGINEER in the form of curves and tables that gave the power which belts of various weights are able to transmit at different speeds, with the correction factors which indicate the necessary allowances to be made when laying out the types of drives mentioned above.

Another article* in the April, 1926, issue of INDUSTRIAL ENGINEER contained added information and data on the relative power transmitting capacities of horizontal and angular leather belt drives. The method of applying the data obtained in the second of this series of tests with the data which appeared in the first article is also explained.

Additional studies have been made recently upon crossed belt drives to determine the characteristics of the drive and, if possible, indicate methods of utilizing this resultant information in establishing methods of laying out such drives.

The 100-hp., laboratory belt-testing apparatus of The Leather Belting Exchange Foundation was used for this work. As this equipment has been described in previous articles no description is necessary here except to point out that the equipment readily lends itself without changes to crossed belt tests because either the driving or driven unit may be run in either direction. Measurements of the torque, revolutions per minute, belt slip, total tension on both strands of the belt, arc of contact on either pulley, and center distance may be taken with this apparatus.

The present experimental work naturally divided itself into two parts. First, transmission tests to determine the power transmitting capacity of crossed belts compared with normal belts; and, second, experiments using various combinations of pulleys, at various center distances, to find out how these factors affect the operation of crossed belts. A common trouble with crossed belts is running off the pulley when under load, which is often prevented by mechanical means such as a shifter fork. This practice is obviously detrimental to the belt. Therefore, the principal object of the second part of these tests was to determine the limiting conditions of pulley diameter and center distance which, if exceeded, would cause the belt to run off.

The experiments were started with two 6-in. belts, Nos. 1 and 2, the former having a buffed grain surface for low-capacity work, and the latter, a normal, high-capacity grain surface. Later other tests were made on two 4-in. belts, No. 3, a light double and No. 4, a heavy double belt, both of which had a normal grain surface. The double belts had been used in other experiments, and therefore required little running in. The dimensions of these four belts are given in Table I.

Belt No. 1 was carefully run in until it gave promise of giving uniform results. Capacity tests were then made on standard 24-in. pulleys at 3,000 f.p.m. to compare the crossed and the normal open drive. A buffed belt was used because a more constant frictional condition can be maintained with this type of belt surface. After making a few experiments to determine some of the characteristics of the crossed drive, another comparison between the two drives was made, using a 9-in. driver and a 36-in. driven pulley at a belt speed of 2,000 f.p.m. In each case the direction of rotation was chosen so as to bring the tight side of the crossed belt onto the bottom of the driver pulley, resulting in greater wrap on this pulley. The tests on the 24-in. pulleys were run at approximately 15-ft. center distances, and those on the 9-in. to 36-in. combination were run at about 10-ft. centers. The results of this test are given in Fig. 1.

At this point the first series of experiments was begun to determine the limitations of the crossed drive. Trials were first made on different combinations of pulleys at three center distances, using the tight side of the belt below and also above the driver pulley; each pulley was tried as the driver when the two were of different sizes. The 6-in. belt was then cut lengthwise into a 2-in. and a 4-in. belt and the complete series of experiments was repeated on these widths. The load was gradually applied to each drive until full load was reached, or until the belt ran over the edges of the pulleys. If the drive carried full load successfully, further load was applied until the belt slipped badly or ran to the edges of the pulleys.

A tension of 175 to 200 lb. per sq.in., which is about average prac-

Table I—Specifications of Four Belts Tested

Belt	Weight	Original Width, In.	Thickness, In.	Original Length, Ft.	Original Length, In.	Weight Oz., Sq.Ft.	Remarks
No. 1	Single	5.96	0.205	36	3/16	15.3	Grain buffed
No. 2	Single	6.15	0.21	35	9 3/4	17	Normal grain
No. 3	Light double	4.01	0.30	29	11	23.6	Normal grain
No. 4	Heavy double	3.96	0.422	29	10 5/8	32.3	Normal grain

*Readers who do not have copies of the June, 1925, and April, 1926, issues of INDUSTRIAL ENGINEER on file may obtain the information on which these previous articles by Mr. Jones were based by requesting Reports R-13 and R-14 from The Leather Belting Exchange, 417 Forrest Building, Philadelphia, Pa.

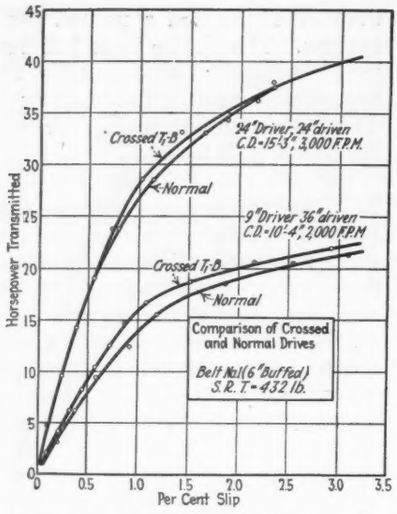


Fig. 1—In these tests the crossed belt transmitted more power than a belt on a normal horizontal drive.

This was probably due to using a buffed belt which did not seem to be affected as much by the rubbing of the belt at the cross as were the standard belts.

tice, was used for all belts. We found after some experiment that tensions higher than this made the belt stay on better, while the reverse was true if the tensions were lower. The belt speed did not seem to have much effect, except that the belt would run off faster at higher speeds once it started. Therefore, no attempt was made to keep the belt speed absolutely constant with the different pulley combinations, although it was generally near 2,000 f.p.m.

Most of the crossed drives fall into two classes: namely, drives where the belt runs to the edge of the pulley at light loads, and those which will carry full load or more without the belt running much off the crown of the pulleys. Practically all crossed belts will run off if they are slipped much above normal. A few, where a very small pulley is used as the driver, will run off one edge of the pulley at no load, and will work over as the load is applied, and tend to run off the opposite edge at overloads. Or, if the large pulley of such a combination is driving, the belt will run off the edge of the small pulley at no load, and will go further off if any load is applied. No drive was considered entirely successful unless the belt would carry full load and stay within 1 in. of the same position on the pulleys while the load was brought to this value.

After belt No. 1 had been reduced to 4 in. in width, transmission tests were made on the 9-in. to 36-in. pulley drive at 10-ft. centers, and 2,000 f.p.m., with the tight side coming on the driver both from below and from above, to determine how much difference, if any, this made. A normal drive test was made at the same time for comparison. The experiments on belt No. 1 gave us the experience necessary to make more thorough and systematic tests on the other belts. The data obtained by testing the 4-in. belt are plotted on the curves in Fig. 2.

Tests were continued on belt No. 2, the 6-in. belt with a normal grain surface, under practically all possible combinations of our laboratory stock of pulleys; these ranged from 4, 6, 9, 12, 18, 24 to 36 in. in diameter. Center distances ranging from 5 to 17 ft. were used. The original 6-in. belt was then cut into a 4-in. and a 2-in. belt and the experiments repeated on these widths.

Transmission tests on the 2-in. width of belt No. 2 at 10 ft. 7 in. center distance, were made on the 9-

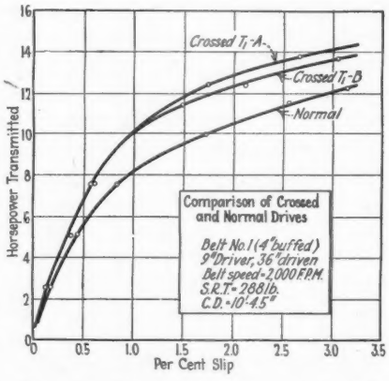


Fig. 2—Here the crossed belts transmitted about 20 per cent more load than the normal belt.

Even though the crossed belt may show higher power-transmitting ability than a normal drive under test conditions it should never be rated higher because the crossed belt is very sensitive to excessive load and slippage and to a decrease in tension.

to 36-in. drive to compare normal and crossed drives, with a high-capacity belt. We had previously noticed that the high-capacity belts did not seem to do as well when crossed and the results of the tests, given in Fig. 3, show this very clearly. These crossed-drive curves stop at about 2.25 per cent slip because the belt threatened to run off at this slip.

Similar experiments were run on the light and heavy double belts, Nos. 3 and 4. These belts were shorter than the singles and, therefore, the various pulley combinations were tried at two center distances instead of three. As we had found in our tests on the single belts that the three widths acted about the same, the tests on the doubles were confined to the original 4-in. belt.

A study of the results obtained up to that time revealed that some of the data were confusing and contradictory, especially on the single belts. Further experiments indicated that the direction of the cross seriously affected the results on the 2-in. belts, and to a lesser extent those on the 4-in. belts. For example, a belt which would not carry more than half-load crossed one way, without running off, might carry full load, or more, if crossed the other way. After this fact was determined all doubtful drives were checked over again with the belt crossed both ways.

Considering first the results of the transmission tests, the horsepower-slip curves of which are plotted in Figs. 1, 2 and 3, the crossed drive gave slightly higher power transmission than the normal drive in the case of the belt with a buffed grain surface, Figs. 1 and 2, while with the belt having a normal grain surface, Fig. 3, the reverse was true. For instance, in Fig. 1 we found that the 24-in. to 24-in. crossed drive at 1½ per cent slip transmitted 3 per cent more power and the 9-in. to 36-in. crossed drive at the same slip transmitted 7½ per cent more power. With the same belt after it had been cut to 4-in. width, the difference between the two curves at 1½ per cent slip, as shown in Fig. 2, is 20 per cent.

The opposite result, indicated in Fig. 3, is probably due to a lowering of the co-efficient of friction caused by the rubbing at the cross. This effect was noticeable every time the high-capacity belts were crossed, because a little running in with these belts on a normal drive would

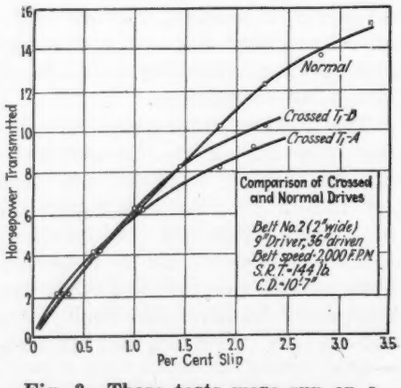


Fig. 3—These tests were run on a high-capacity belt.

In this case, which approximates normal operating conditions, the normal horizontal drive transmitted the heavier load. A 9-in. pulley drives a 36-in. pulley on 10 ft. 7-in. centers.

bring up their capacity, and it would drop off again when they were put on the crossed drive.

It is likely that the buffed surface was not subjected to this action, so that the difference between the two drives, as indicated in Figs. 1 and 2, is more nearly correct. Although the transmitting capacity of the crossed drive was slightly superior to the normal drive, averaging about 10 per cent for the three comparisons, the crossed drive is, under most conditions, very sensitive to excessive load and slippage and, therefore, it should not be rated higher than the normal drive.

The difference in the power obtained in the two cases, where the tight side of the belt is below and above the driver pulley, is small. In one case the tight side above transmitted more power, while in the other case the tight side below transmitted more power. Evidently there is little to choose between the two conditions, so far as power transmission is concerned.

A clearer understanding of the meaning of the terms "tight side below" *(T_1-B)* and "tight side above" *(T_1-A)* may be obtained from Fig. 4, a line drawing of a crossed belt drive. The arrows at the driver pulley indicate which way this pulley must turn for tight side to be above or below.

A few general conclusions, dealing principally with the ability of crossed belts to stay on the pulleys at full load, were made from a study of the data obtained. They are as follows: First, there is a minimum center distance for every combination of pulleys, below which a belt under average tension will not carry full load without giving trouble, although it may carry some portion of its load. Second, belts in widths ranging between 2 in. and 6 in. behave in about the same manner, for most of the pulley combinations, and have approximately the same minimum center distance, with a few exceptions. Third, the ability of a belt to operate well on a crossed drive partly depends upon the amount of initial tension used, and belts under high tension will work at shorter center distances than those under low tension. Fourth, belt speeds up to 5,000 f.p.m. have little effect on crossed belt operation, except that due to the usual reduction of capacity caused by centrifugal force. Fifth, double belts act approximately the same as singles, but they tend to stay on the pulley a little better; thus in some cases they can be operated at shorter center distances. Sixth, a small pulley driving a large one is a more stable drive than a large pulley driving a small one and gives a drive which can be operated on shorter centers.

For practical use the operating data have been condensed into Table II, which is divided into two sections, one for single belts and the other for double belts, which give the minimum center distances at which the various crossed drives will carry full load without a troublesome tendency on the part of the belt to run off. The driver pulley diameters are placed horizontally across the top, and the driven pulley diameters are given vertically on the left edge. The letters *B* and *A* in the vertical columns indicate whether the tight side of the belt should be below or above the driver pulley as the belt comes on it. The intersection of the vertical *B* or *A* column under the driven pulley diameter with the horizontal column opposite gives the minimum center distance in feet for the drive. Several references in the single belt table are used to indicate different center distances for certain widths. Small *c* means that the value given could not be determined experimentally, and was therefore calculated or estimated. In a few cases where the data did not warrant an estimate, no value is given. It should be especially emphasized that in case the belt does not work well at or above the center distance given, the cross should be reversed.

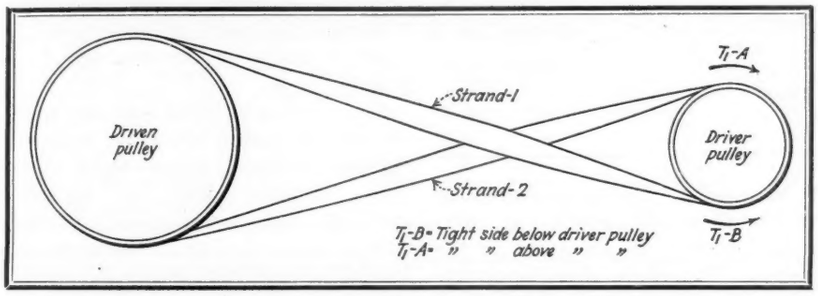


Fig. 4—The arrows show the direction of rotation with the tight side of the belt above and below.

More stable operation of a crossed-belt drive results when a small pulley is driving a large one. Frequently when a crossed belt continually runs off the pulley the difficulty may be remedied by crossing the belt in the other direction. This does not mean, however, to twist the belt so that the grain side is the driving side against one pulley and the flesh side against the other pulley.

Most of the drives within the range of these tables will carry light loads well at a center distance 25 per cent less than is given here, but for full load these drives would probably require some mechanical means of holding on the belts, such as a shifter fork. Results of the tests would indicate that it is not advisable to use for any drive center distances less than 75 per cent of those indicated in the tables. It seems that there is no practical upper limit of center distance, although at long distances the belt might begin to flop, which would cause the drive to be unstable.

The drives within the range of the experiments thus naturally fall into three classes:

(1) Those using center distances as great or greater than indicated in the tables, which can be expected to transmit full load, but not overloads.

(2) Those using center distances between 75 per cent and 100 per cent of the table value, which will carry light loads, but probably not full load without mechanical help to keep the belt on.

(3) Drives at center distances less than 75 per cent of the table value are practically sure to be unsatisfactory.

However, it should be remembered that even drives in the third class can be made to work temporarily if sufficient tension is used on the belt. Also, the reverse is true in that drives in the first class may cause trouble if they are not kept tight enough. The tables apply to belts under average tension, but are liberal enough to allow for considerable variation in tension, providing the belt does not slip excessively.

Belts may be occasionally found which seem to be operating all right at shorter center distances than these, but the chances are that the belt is very tight or it is lightly loaded, or it may be held in position by a shifter fork or some other obstruction. The author frequently has had an opportunity to check these tables against actual installations, and has almost invariably found the above to be true.

Misalignment of the shafts, or moving one pulley on its shaft, might occasionally help to keep the crossed belt on the pulleys, but our experiments indicate that little can be

gained by these devices. If the shafts are thrown out of alignment to keep the belt on at full load, it will tend to run off the opposite edge of the pulley at lighter loads, and *vice versa.* Or, if one pulley is offset the belt will tend to follow this pulley, and remain in about the same position on the pulleys. If the load is very constant, offsetting of one pulley may sometimes be used to advantage. Misalignment of the shafts should never be recommended. The center distances given in the tables are based on perfect alignment of the pulleys and shafts.

With any crossed belt under load the force tending to keep it on is the climbing action of the belt on the crown of the pulleys. The principal force tending to push it off is the pressure of the tight strand of the belt against the loose strand where they cross. As the load is increased the tension on the loose side is decreased. Naturally, the tight strand displaces the loose strand and forces it from its path so that it approaches the driven pulley at a slight angle. The greater the load the greater this angle becomes, until the practical limit is reached at the point where the tight side has nearly displaced the loose side. This displacement is greater than it appears at first thought because of the twist in the strands. Therefore, there is always a force tending to run the belt off the pulleys, but it depends upon the pulley sizes and center distance whether or not this force is great enough to overcome the climbing force caused by the pulley crown.

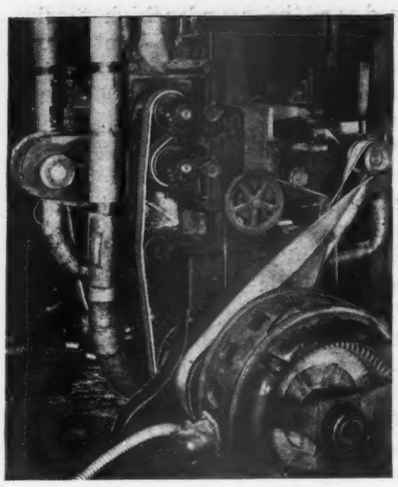


Fig. 5—Here is an example of a short-center belt drive over a small pulley.

This illustration shows very clearly the way one strand of the crossed belt pushes against the other. This small pulley is provided with a flange to keep the belt on. Courtesy of Chicago Belting Co., Chicago, Ill.

When a small pulley is used with a larger one, as illustrated in Fig. 4, the point where the two strands of the belt cross is nearer the smaller pulley. As the loose side, which is forced aside at the cross, always comes on the driven pulley, this force will be applied nearer the driven pulley when the larger of the two pulleys is driving. Therefore, for any given pulley combination, the minimum center distance for stable operation will be greater when the larger pulley is driving. Anyone who has tried to run a belt off with a stick has noticed that it is much easier if the force is applied on the loose side near the driven pulley, instead of half-way between the two pulleys.

To illustrate further, suppose that the smaller pulley in Fig. 4, is driving and strand-1 is the tight side. Then strand-1 will be forcing strand-2 aside as it comes on the larger pulley, but since the cross is too far away from the large pulley this force is not sufficient to overcome the effect of the crown. If the larger pulley is driving with strand-1 as the tight side, strand-2 is being forced aside much nearer the small pulley, which it is approaching, and the belt is more likely to run off. It is desirable to have the point of crossing 4 ft. or more from the driven pulley, depending on the pulley combination used. Reversing the cross is frequently of benefit.

The same reasoning applies in explaining why an increase in tension makes the crossed drive more stable. When the initial tension is increased, there is a readjustment upward of the actual tensions in the two strands, so that the loose side is carrying a greater proportion of the total tension than it was formerly. The result is that the loose side, being under a greater relative tension, will not be pushed aside to the same extent until greater loads have been reached. Furthermore, the climbing action due to the crown probably becomes greater as the tension is increased.

Briefly some of the more important results and conclusions on the operation of crossed belts are as follows:

(1) The crossed belt transmitted 10 per cent more power than the normal belt in an average of three tests, but as it is more unstable in operation no higher power rating is recommended.

Table II—Minimum Center Distances for Crossed Belt Drives

Maximum Center Distance in Feet for Single Belts

Driven Pulley, Diam. in In.	Driver Pulley Diameter 4 In. B	4 In. A	6 In. B	6 In. A	9 In. B	9 In. A	12 In. B	12 In. A	18 In. B	18 In. A	24 In. B	24 In. A	36 In. B	36 In. A
4	..	..	..	..	..	..	13	*c*18	*c*†22	...	....	...	...	...
6	..	..	..	..	..	..	12	*c*14	*c*†18	*c*20	*c*†20	*c*22	...	...
9	..	..	..	..	..	..	9	9	12	12	15	*c*17	...	...
12	*10	*10	8	8	8	8	8	8	9	9	11	11	*c*18	*c*20
18	*10	*10	8	8	8	8	8	8	9	9	10	10	*c*15	*c*17
24	10	10	8	8	8	8	9	9	9	9	10	10	11	11
36	10	10	10	10	10	10	10	10	11	10	11	10	14	13

Maximum Center Distance in Feet for Double Belts

Driven Pulley, Diam. in In.	Driver Pulley Diameter 6 In. B	6 In. A	9 In. B	9 In. A	12 In. B	12 In. A	18 In. B	18 In. A	24 In. B	24 In. A	36 In. B	36 In. A
6	..	..	..	..	16	16	*c*16	*c*18	*c*20	*c*22	...	...
9	..	..	..	..	8	8	9	9	12	12	...	...
12	8	8	7	7	7	7	9	8	9	9	*c*17	*c*19
18	8	8	7	7	7	7	7	7	9	9	11	*c*15
24	10	10	7	7	7	7	7	7	7	7	11	12
36	10	10	8	8	8	8	9	9	10	10	15	10

DIRECTIONS FOR USE ON BOTH TABLES:
Use for belts up to 6 in. wide.
Reverse cross if drive does not work well.
B and *A* indicate tight side below or above driver pulley.
* For belts below 3 in. wide use 8 ft. center distance.
† For belts below 3 in. wide use 17 ft. center distance.
c Calculated or estimated.

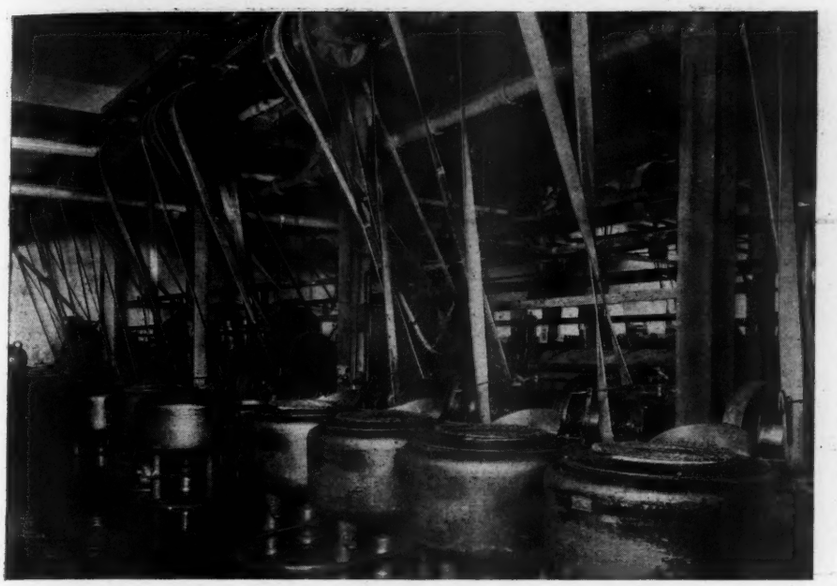


Fig. 6—Many of these centrifugal machines in laundries use crossed belts on tight and loose pulleys.

This type of service throws a heavy load upon the belt drive whenever the belt is shifted onto the tight pulley. These center distances, however, are great enough to prevent belts running off the pulley. Courtesy of Chicago Belting Co., Chicago, Ill.

(2) Every crossed drive seems to have a minimum center distance below which the drive is unstable and its performance unsatisfactory.

(3) Using the smaller pulley as the driver makes a more stable drive, and it can be operated at a shorter center distance than when the large pulley is used as the driver.

(4) The higher the initial tension, the more load a crossed belt will carry without running off.

(5) Belt speed does not affect the performance of a crossed belt, except for the usual effect of centrifugal force on its transmitting capacity.

(6) Belts of any width up to 6 in. seem to work about alike on the crossed drive, with a few exceptions noted in the tables.

(7) Double belts work a little better than singles on many crossed belt drives.

(8) Using the tight side of the belt above the smaller pulley, whether it is driving or driven, is a more stable condition than using it below.

(9) The rubbing at the cross tends to reduce the co-efficient of friction, more or less depending on the belt.

The direction of the cross has an important effect on crossed belts, because one edge of the belt is usually a little longer or more elastic than the other. If the longer edge is on the wrong side the crown will not hold the belt on as well as though the cross were reversed. The cross may be reversed by removing the belt from one pulley and untwisting one-half a turn as if to put on an open drive and then twisting another half turn in the same direction. This changes the position of the two strands at the cross, so that the tight side tends to force the loose side off in the opposite direction from that in which it did before. When a crossed-belt drive which has been correctly laid out refuses to work properly the trouble can usually be remedied by reversing the cross.

Arc Welding in Maintenance Work

(Continued from page 266)

Recently new tubes were arc-welded in the top sheet of a locomotive crane. Plans are under way to arc-weld in the tubes at both ends in another locomotive crane in which the tubes must be renewed shortly.

The hood and smoke pipe on a large blacksmith's forge in the repair shop were constructed by arc-welding the steel sheets together. The repair men have also used the welder to a considerable extent in building up miscellaneous fixtures around the repair shop as, for instance, horses for holding work. They also built up a light, portable forge which can be connected onto an air line anywhere in the plant.

In dismantling parts which have been riveted together, the torch is used for cutting out the rivets; frequently the new parts are arc-welded.

There are, of course, numerous broken castings which must be welded. Those of cast iron, and sometimes cast steel, are usually welded with the acetylene unit and are preheated on our special bench.

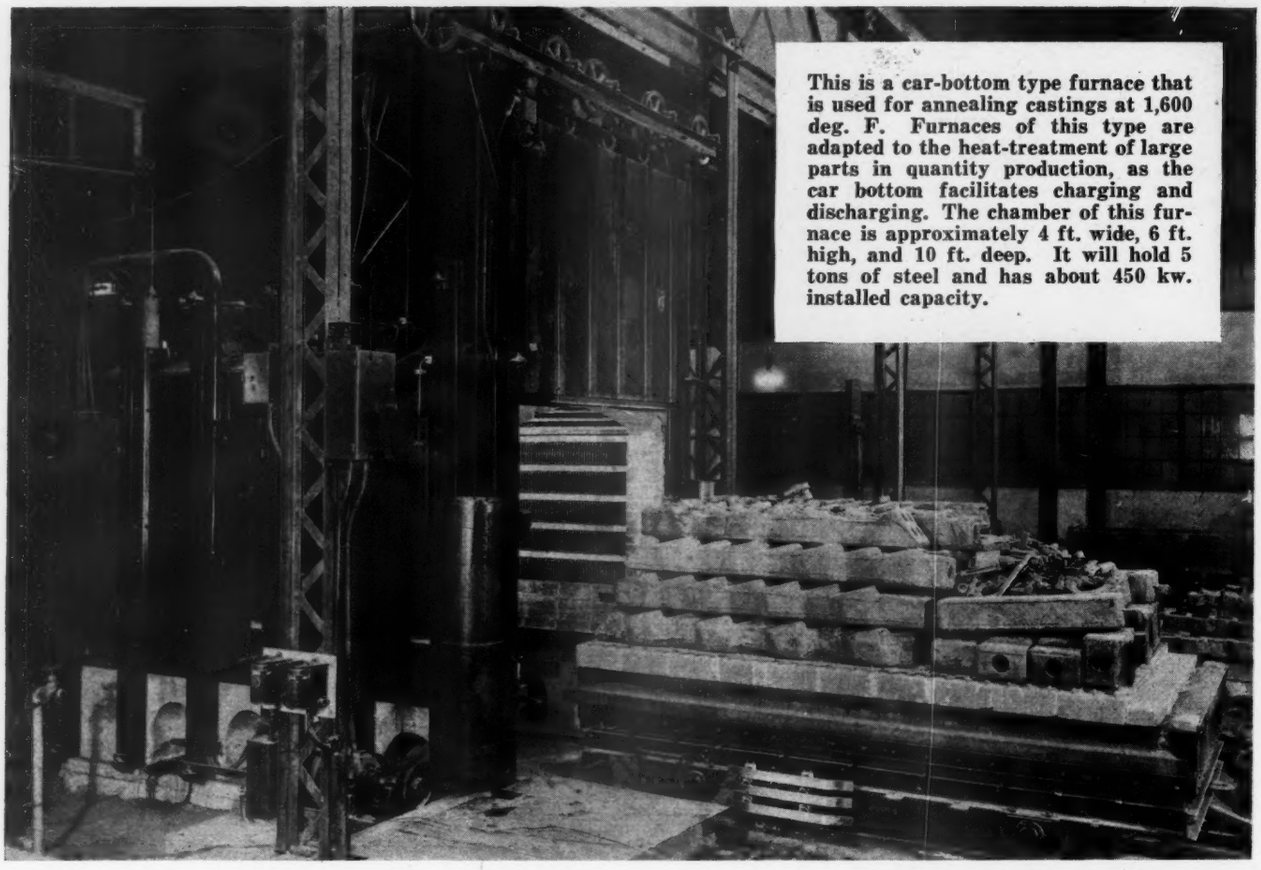
The gas-cutting and arc-welding units are used in combination on a wide variety of jobs. A recent job, for instance, consisted of constructing some special brackets from ½-in. steel plate. These brackets had two bends, each of about 120 deg. Instead of heating up the steel plate in the forge and then making a hot bend, the welder cut a slot through the plate, except for about ½ to ¾ in. at the edges, or just enough to hold the plate together, at the place where the bend was to be made. The bends were then easily made cold, and also very accurately. After bending the plate, the slot was filled in with the arc welder. A 1½-in. by ⅜-in. flat bar was bent into a half-circle and welded into a semi-circle cut into the top of the plate. This formed a saddle to hold the gasoline tank on a special industrial truck. One of these pieces is shown in the group of welded parts in the illustration on page 266.

This list by no means represents anywhere near the amount of work done. The group of jobs illustrated indicate only those in the shop at the time the photographs were taken.

At first we intended to use the welding units only to repair broken parts; now, however, the use in building up new parts equals if not exceeds the time spent in the actual repair of old work. Every day we are finding something new to weld.

It is our aim to provide a variety of electrodes so that any type of work may be handled. Only small amounts of some of these types are used; others are used in considerable quantities. The accompanying list shows the different types of electrodes carried in stock and the average quantities used monthly. Where the table mentions "small amount," this indicates that the particular electrodes are carried in stock but are used infrequently.

Because we use one type of welder for certain classes of work and the other welder for other jobs should not be taken to mean that this is the best or only way. Another operator with different training might handle our welding work in other ways, to suit his training and experience. However, we are well satisfied with our method of dividing the work, which in general follows the lines described, although this is not a hard-and-fast rule.



This is a car-bottom type furnace that is used for annealing castings at 1,600 deg. F. Furnaces of this type are adapted to the heat-treatment of large parts in quantity production, as the car bottom facilitates charging and discharging. The chamber of this furnace is approximately 4 ft. wide, 6 ft. high, and 10 ft. deep. It will hold 5 tons of steel and has about 450 kw. installed capacity.

Factors that determine when

Electric Heating Can Be Used to Advantage

in industrial plants, with a discussion of the operating economies and desirable features that are inherent in this mode of heating

By WIRT S. SCOTT

Special Representative, Industrial Heating, Westinghouse Electric & Mfg. Co., Mansfield, Ohio

TWELVE years ago, when the first real start was made in the study of industrial heating problems, almost nothing was known of the economies that might be expected to result from the use of electric energy. A prospective user who was willing to let an electrical manufacturer conduct experiments in his plant, at the expense of said electrical manufacturer, was exceeding the height of magnanimity.

Everyone was skeptical and most people positively antagonistic, due to their accustomed practice and usage of fuel-fired equipment, which had been handed down from one generation to the next.

As years went on and the usage of electric heat increased, the time approached for encouraging the user to make preliminary investigations himself for the purpose of calling attention to the advantages of electric heat when applied in his manufacturing processes.

Today, due to the fact that sufficient interest has at last been aroused and a sufficient number of diversified installations have been made, the time is opportune for showing the industrial plant operating executive how to convince himself as to whether or not he should use electric heat, and after he has decided for himself, to see that he gets the proper kind of apparatus to perform his heating operation most efficiently and economically. The equipment may be especially designed, if need be, to meet his particular plant conditions.

Electric heat has a definite field of operation at the present time. In listing the following conditions of operation that may exist in an industrial plant, it is not done with the intention of dwelling on the advantages of electric heat, but rather for the purpose of showing definitely wherein electric heat is applicable and will prove to be commercially economical.

(1) In a plant producing the highest-grade article, where a new standard of comparison will be of advantage from a business standpoint, electric heat will make it possible to set up new standards.

(2) When a good product is already being secured, electric heat will make it possible to produce a better product.

(3) When a non-uniform product is being secured, electric heat will

make it possible to produce a uniformly high grade of product, with elimination of rejects and reduction in the amount of labor required, resulting in lower cost of production.

(4) When continuous and uniform production of a good product is required, electric heat will give continuous output with elimination of rejects.

(5) When the present grade of product is satisfactory, electric heat will oftentimes permit the use of less expensive materials.

(6) When a lighter product is desirable, or where a saving could be effected through the use of lighter materials, provided these have sufficient strength, electric heat will make possible such savings. Through its use the utmost strength or hardness can be imparted to the materials, and these results can be duplicated day after day, continuously.

(7) When it is desired to reduce the amount of labor to a minimum, electric heat will make for reduced labor in operation of apparatus, reduced labor in handling materials, and reduced labor in maintenance of equipment.

(8) Where it is desired to improve working conditions, the use of electric heat will result in elimination of hot gases that must be breathed by the workmen, elimination of overheated workrooms, increasing efficiency of labor, provide better humidity conditions, and permit of more definite control of ventilation.

Heat in some form enters into the production or fabrication of all manufactured materials. The quality or characteristics of the final product depend upon the exactness of the heat-treatment. Inferior raw material that is properly heat-treated may provide a much better product than will a superior raw material that is improperly heat-treated.

Heat in one way or another affects the quality and cost of practically every manufactured article. The problem resolves itself into selecting the combination of raw materials, methods, production equipment, facilities, and personnel, which when properly adapted to individual manufacturing requirements and plant conditions, will most nearly accomplish the desired results; that is, the production of a quality product at a minimum cost. Quality and cost of the finished product are the basic factors that must always be considered.

Fuel cost is but one item in the final cost of production, and in most cases it is only a small item in the total cost of the finished product. The cost of fuel or power may influence, but certainly does not determine, the cost of the completed product. Electric heat is the ideal heat, and in many cases it is the most economical means of heating, when all factors are considered.

Electric Heat Permits Close Time and Temperature Control

The development of heat-treating processes to a high plane has been practically impossible in the past, due to the nature of the fuels available. To secure a predetermined product, it is essential that the complete time-temperature cycle of operation be under definite control, that the heating be done in a chamber having uniform temperature distribution, in an atmosphere free from products of combustion, and in a minimum length of time. With combustion fuels, these results can be only approximated, and with no definite assurance of duplication day after day of a uniform product.

With fuel-fired furnaces a metallurgist, physicist or chemist will take a sample piece of his product, accurately determine by a series of experiments in a small electric furnace the best time-temperature cycle of operation, and turn these specifications over to his shop with the expectation of this result being duplicated in a furnace incapable of reproducing the conditions obtaining in the laboratory experiments. Appreciating more or less the limitations of fuel-fired furnaces, metallurgists and operators both have adopted the results obtained as standards of best practice, and have had to adapt their materials to the nature of the heat-treatment, instead of adapting the heat-treatment to the nature of the material.

There is now on the market dependable electrical heating apparatus for securing these results. This apparatus is capable of duplicating in shop practice, day after day, continuously and entirely automatically, an exact or defined time-temperature cycle, as required by the specifications.

Every known kind or piece of material heated has its quality affected by the heat-treating process. Also, every known material has some definite best temperature for producing the best quality possible with the material used. The nearer one approaches to these ideal conditions, the nearer perfection will be secured in heat-treatment work. Likewise, the farther one departs from the ideal best temperatures, the less satisfactory will the product be.

The advantages to be gained by using electric heat will depend upon the specific application. In the applications now in general use, it produces certain results that might be said to be inherent with electric heat. These results are, uniform high-grade quality of product, increased production, reduced expenditure for labor, better working conditions, and lower over-all operating results. These are a logical consequence of

Here is a special furnace that was built for a special job.

This 15-kw. furnace is used for annealing turbine blades at 1,300 deg. F. This is a case where it was more economical to build a special furnace than to use one of standard construction and design.

the fact that electric heat is the most flexible and the easiest-controlled form of heat that can be used.

The truth of these statements will be readily appreciated by considering the following points:

(1) Heating units, in suitable form, may be distributed in an oven or furnace or attached to a tank, table or machine, in the correct manner to give a uniform distribution of heat, in just the quantity desired. Once these conditions are secured, they become fixed for all time, and are not subject to change or variation, as when a combustible fuel is used. This condition results in a better product, increased production, and increased output per unit of floor space or for each piece of apparatus.

(2) By means of automatic temperature control, the work will not be overheated nor underheated, but maintained at the correct temperature, continuously and automatically.

(3) By means of electric heat, automatically controlled, tests can be made to determine the proper rate of heating, the best temperature for accomplishing the desired results, and the length of time the work must be subjected to a given temperature to produce the desired results. Once these conditions are determined, the desired product can be reproduced day by day, automatically, with the same uniform results. Electric heating has made possible the duplication of laboratory experiments in shop practice.

The greatest progress in the application of electric heat has been made with manufacturing plants that keep accurate cost records of each phase of operation affecting the cost of the completed product. Factors that affect costs were not overlooked, and these plants were in a position to determine the value of electric heating by an accurate comparison of this with other methods of heating, taking everything into consideration. The cost of fuel or power is only one item affecting costs.

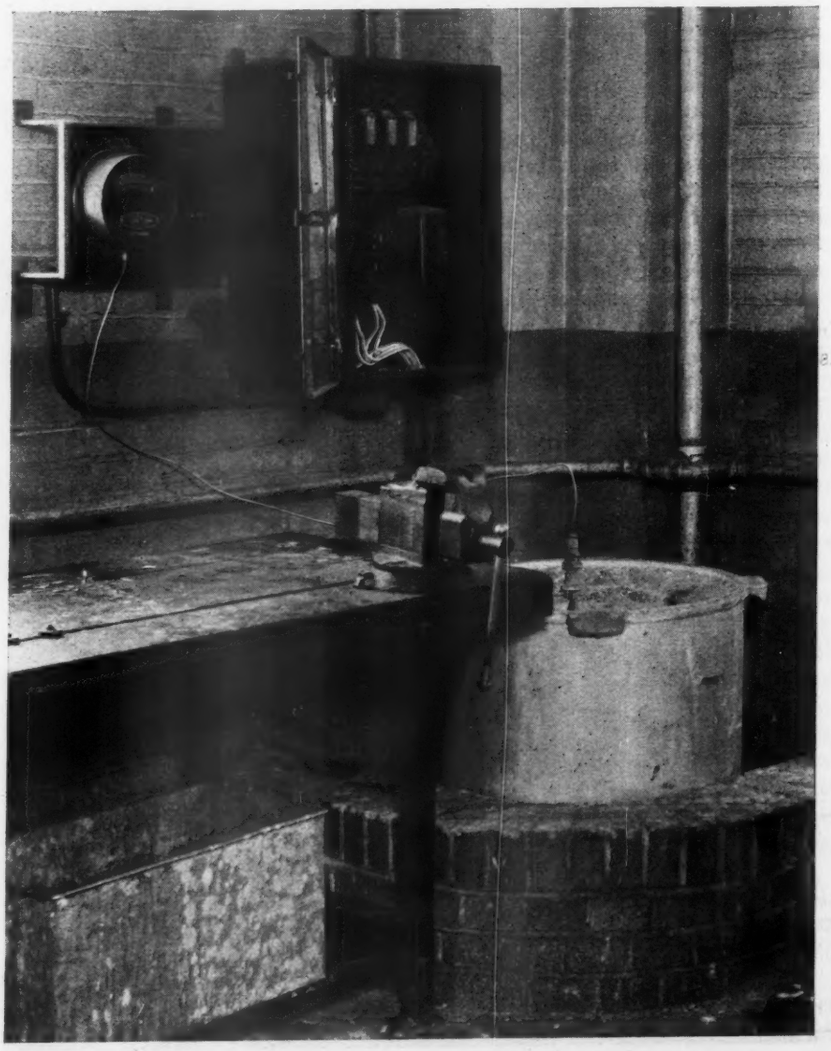
Making an Investigation of Operating Conditions in the Plant

The first step in an industrial electric heating investigation must be made for the purpose of securing a detailed knowledge of the operating conditions. Consideration must be given to all phases contributing to the production of the completed product. Among these factors are:

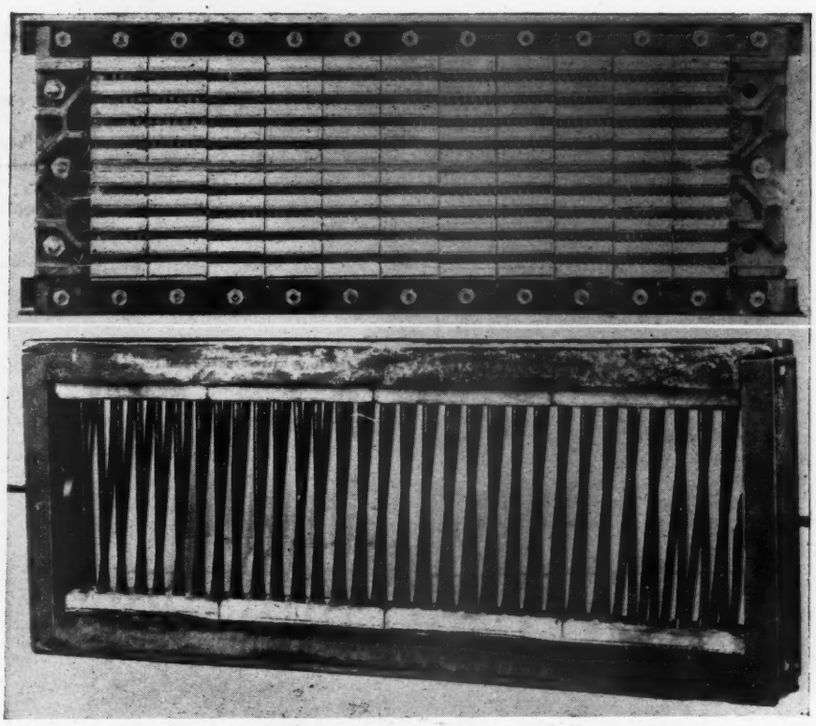
Quality of Product—A high-grade quality of product has a high sales price. The finished product may be made up of a number of component parts requiring the use of heat during some stage of manufacture. Determine what these parts are. It will then be in order to find out how much more could be obtained for the product, or how much sales could be increased if a better product were possible.

Uniform Product — A *uniform* product is desirable, whether it be uniformly good, uniformly fair or uniformly poor. If a product is excellent one day and only fair the next, or is otherwise non-uniform, the manufacturer is saddled with an unnecessary expense, for the following reasons: (1) Where the manufacturer demands only a high-grade product, all production that does not come up to such specifications must be rejected. Consequently, the cost of producing material which does meet the specifications is increased, resulting in increased selling price or decreased profits. (2) Where the product is sorted into two or more grades, a lower price must necessarily be obtained for the inferior grade or grades. (3) Where the entire product is sold as one medium grade, the manufacturer is penalized for his inability to produce all high-grade material, through the production of an excessive amount of low- or second-grade material.

The first step is to determine the reason for non-uniform product. If this can be traced to the heating of any component part of the material, in any stage of its manufacture, determine the cause as accurately as possible. There may be several contributing factors, such as (*a*) incorrect temperature to produce the best results. To check this point, tests can be made in a small oven or furnace on samples and the correct



This 750-lb. melting pot is used for tinning leads and terminals for electrical equipment. The control panel can be seen mounted on the wall at the left.



These are heating units used in electric furnaces.

The upper view shows a medium-temperature unit rated at 2.5 kw. at 900 to 1,300 deg. F. or 5 kw. up to 900 deg. F. It may be operated directly on 110 or 220 volts. In the lower view is a high-temperature heating unit with a rating of 8 kw. at 1,800 deg. F. or 1,600 kw. at 1,500 deg. F.

temperature determined for securing the quality of product desired. These conditions can then be duplicated, automatically, day after day, by the use of electric heat. (*b*) Inability to control the temperature within close limits. By means of electrically controlled heating equipment, the temperature of any heating operation can be made simple, reliable, automatic, and as close as may be desired. (*c*) Heat not applied uniformly. Electric heaters in suitable form can be applied to any process, to give a uniform distribution of heat continuously and automatically. (*d*) Heating done too slowly or too rapidly. By the use of electric heating equipment, a system of control can be used which will accommodate itself to any cycle of heating operation so as to heat the material at the predetermined rate found from experience to produce the best results. (*e*) Work injured by a high flame temperature. Electric heat-treating is accomplished at relatively low temperatures, the temperature of the heating elements never being many degrees above the temperature of the work, so that there is little danger of local overheating.

Production—The items entering into production, in so far as heating is concerned, that affect the cost of the finished product, are: (*a*) Interruptions caused by the failure of the heating medium, which may be due to failure of the equipment, shutdowns for repairs, or failure of the source of heat. (*b*) Reduced production due to difficulty in retaining skilled labor. (*c*) Non-uniform production due to the human element in the handling of material or operation of the heating device or apparatus. (*d*) Overhead charges for labor, supervision, plant equipment and floor space. (*e*) Number of rejected parts and number of parts that have to be reheated in order to pass inspection. (*f*) Additional labor required in other departments, to handle material that has been rejected or is defective due to improper heating.

Considering heating operations, the items that influence the cost of the labor involved in turning out the finished product are: *Labor*—(*a*) Labor required in handling the material. (*b*) Labor required in operating or supervising the operation of the heating device or apparatus. (*c*) Saving in labor if conveyors or trucks could be used. (*d*) Saving in labor if the heating operation could be made automatic. (*e*) Effect on the workmen of present conditions, such as exposure to excessive heat, or the breathing of gases and poisonous fumes.

Fires or Explosions—These have been the cause of much property damage and loss of life. They may be due to the form of heating medium, kind of heating apparatus used, careless workmen, nature of material heated, and a number of other factors.

Inasmuch as fires and explosions do not occur every day, it will be necessary to go back over the records for a period of years to determine whether any have occurred, and the extent and nature of the damage done.

Maintenance—In the maintenance work required for the heating equipment, following items should be considered: (*a*) Annual repairs to heating equipment, taken over a period of a number of years. These repairs should include all labor and material used in making such repairs. (*b*) The cost of operating all auxiliary equipment, such as blowers, compressors, and the like. (*c*) The handling charges for fuel, such as oil, coal, coke, and so on.

Penalties—Every plant that does not utilize electric energy for manufacturing processes that require heat is, to a greater or less extent, penalizing itself by not doing so; therefore, such penalties must be charged up against the present heating process as a direct expense. Among the items that must be considered from this standpoint are: (*a*) Low power factor. Heating equipment, with the exception of arc furnaces, operates at unity power factor, and will raise the power factor of any industrial plant. If the heating load is of considerable magnitude it will make it possible to obtain a better power rate of the entire electrical load of the plant. (*b*) Power rates. The addition of a heating load greatly improves the load factor and will make possible lower power rates for the entire electrical load of the plant.

A thorough analysis of these items will serve to establish a definite basis for the formulation of plans to improve present operating conditions, and enable the plant engineer to determine the influencing factors entering into the cost of the completed product. Only in this way can an intelligent selection of equipment be made.

After the above conditions have been accurately determined, and not until then, the cost of fuel, compared to the cost of electric energy for heating processes, may be given due consideration.

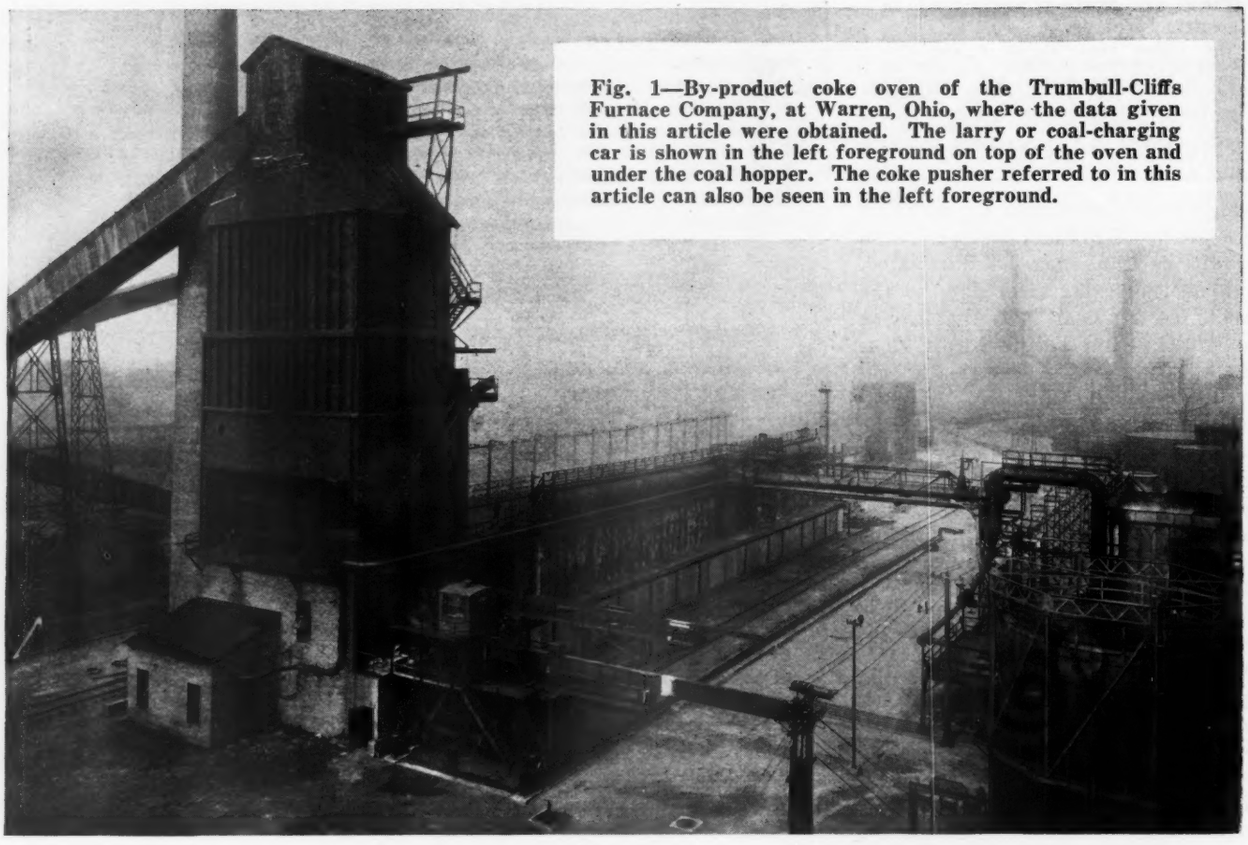


Fig. 1—By-product coke oven of the Trumbull-Cliffs Furnace Company, at Warren, Ohio, where the data given in this article were obtained. The larry or coal-charging car is shown in the left foreground on top of the oven and under the coal hopper. The coke pusher referred to in this article can also be seen in the left foreground.

Improving control operation by

Changing Resistance on Motor Controllers

used in a blast furnace and coke plant, together with a discussion of causes of troubles encountered and diagrams showing method of overcoming them

By O. C. CALLOW
Chief Electrician, Trumbull Cliffs Furnace Co., Warren, Ohio

IN THE application of variable-speed motors on machinery, a hazardous guess is often made as to the horsepower required of the motor. With the tendency of the designer to be on the safe side, the motors chosen are often too large for the job and if they are series wound, the speed of the equipment will frequently be much higher than was intended. This in turn affects the control of the motors, as the control manufacturer is called upon to furnish a controller which will be suitable to stop and start the motor to be used and supplies a standard controller for this rating together with standard resistance.

When series motors are used, overmotoring with its corresponding overspeeding will soon show up on the controllers, since there will be more "inching" in order to get slow operation of the driven equipment. By "inching" a controller is meant the operation of repeatedly moving the controller to the first point and then to the off position, thereby intermittently applying power and causing the motor to run slowly. It is, therefore suggested that every drive in a new installation should be carefully watched for the first few months to ascertain whether any improvements in operation could be made by using different values of resistance to help slow up any motors where excessive speed is causing trouble, thereby lengthening the life of the controllers and also of the mechanical drive equipment.

As an example of what improvements can be made in this line I will cite the case of a quenching locomotive in a coke plant. It pulls the quenching car which receives the hot coke as it is pushed from the oven and carries it to the quenching tower where water is poured over the car, thereby stopping further combustion of the coke. The equipment on this quenching car consists of two 90-hp., series-wound motors controlled by a series - parallel, manually - operated, drum controller. In pushing an oven the coke is to be distributed the whole length of the quenching car. This is done by moving the car forward as the oven is pushed. With the original equipment this was done by "inching" the controller on the first point, 22 times for each oven pushed; this meant breaking the acceleration current of the two 90-hp. motors over 2,000 times a day with the natural result that controller repairs were more frequent and costly than they should have been.

After a little study of this condition an extra bank of resistance

having an ohmic value of about 40 per cent of the total resistance was installed in the first step, as shown in Fig. 2. The amount of this additional resistance was adjusted during operation until it was found that with the controller placed on the first point when the coke commenced to fall in the car from the oven being pushed, the speed of the car would be just fast enough for it to travel its own length while the coke was falling, thereby distributing the coke from the oven evenly in the car. The operator is, therefore, relieved of the duty of "inching" and the movement of the car becomes nearly automatic on the first point of the controller. After the oven is pushed, he speeds up the car and proceeds to the quenching station as usual. The extra resistance is also of an advantage here in spotting, especially as the rails are wet at all times and wheel spinning is very likely to occur. Use of the additional resistance has eliminated all wheel spinning of the car while in the quenching tower. The installation of the extra resistance in this particular case was taken care of by the locomotive manufacturer when he was advised of the trouble. In any event the cost of the extra resistors would very soon have been saved in control segments and fingers, and in the labor of installing these.

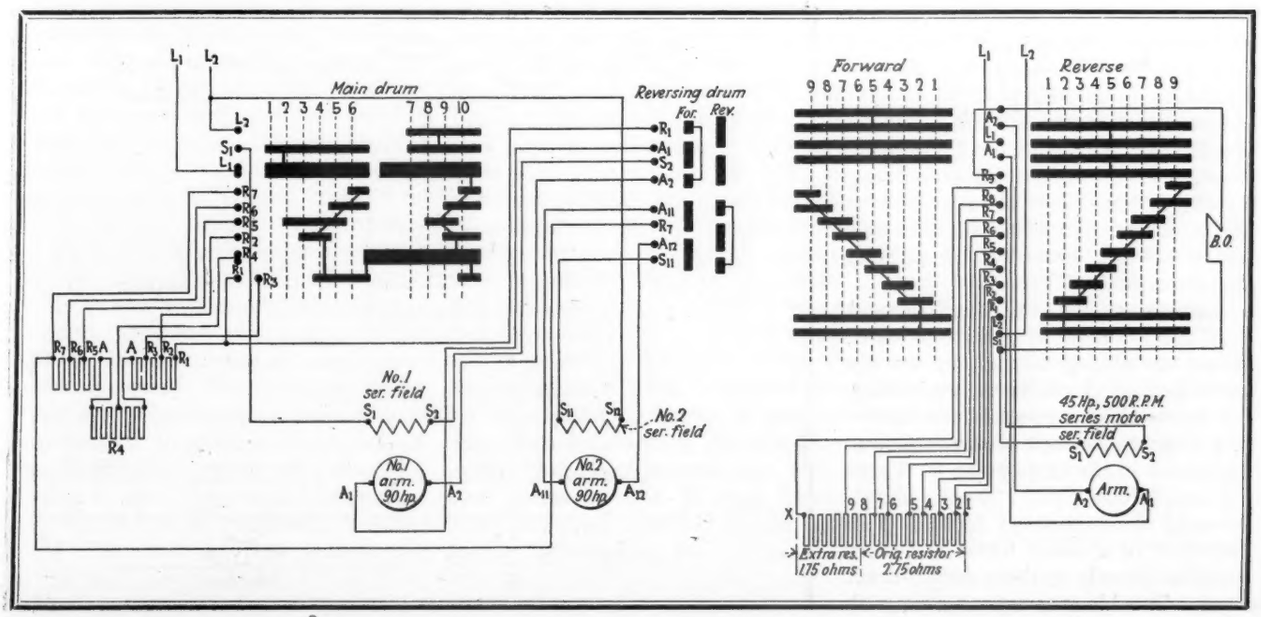
Another installation on the same battery of coke ovens was improved in a similar manner. The larry car (seen under the coal hopper in Fig. 1) that charges the coal into the top of the ovens has no need for high speed on the bridge or propelling motion, for the distance traveled on the top of the battery is short, as may be seen by inspection of Fig. 1, and normally a good deal of "inching" is required to spot the car hoppers over the charging holes in the ovens. This car is driven by a 45-hp., 500-r.p.m., series-wound, mill-type motor and controlled by a standard, manually-operated, reversing; drum controller provided with standard resistance.

Trouble was experienced on this drive by the operator plugging his controller too rapidly while the car was moving at high speed, thereby causing burning of the controller parts and sometimes opening the substation circuit breaker, causing a delay on the battery. Plugging a motor is the operation of reversing the power supply applied to it while the motor is running in a given direction. This action causes the motor to slow down, stop, and start in the reverse direction. By plugging the motor the need of a separate service brake is eliminated, for the plugging operation performs the braking required. As a cure for the trouble encountered, an extra resistance was added to the accelerating resistance, in this case consisting of a bank of grids and connected as shown in Fig. 3. The contact finger at *R*9 was removed so that it is impossible for the operator to cut out the new resistance in any position of the controller; hence this additional resistance is permanently in series with the armature. The original resistor had an ohmic value of 2.75 ohms divided into eight steps; the extra bank installed has an ohmic value of 1.75 ohms and has a current-carrying capacity equal to the full-load current of the motor. This resistance not only acts as a plugging resistance, but also limits the acceleration and running speed of the car, so as to make it more suitable for the short run required.

Another interesting problem was involved in the mechanical operation of the door hook on a coke oven pusher. The door hook removes the oven door from the pusher side of the oven so that the pusher ram may be placed against the hot coke and push it out through the opposite end of the oven. The coke pusher may be seen in the center foreground of Fig. 1. The door hook is on the oven end of the pusher. This hook takes very little power to operate, so the smallest mill-type motor available was installed, this being a 2-hp., 900-r.p.m., series-wound motor. It was found that unless the operator was very careful in his manipulation of the controller on this drive, he would over-run the travel of the nut on the driving screw, causing it to jam.

Figs. 2 and 3—Increasing the amount of resistance used on these controllers greatly improved motor operation.

In Fig. 2 is shown the diagram of a series-parallel drum controller for two motors used on an electric locomotive. Additional resistance was connected between the points *A-A* so as to eliminate the "inching" of the controller formerly required. Fig. 3 shows how an extra resistor was connected permanently in series with the armature of a larry car delivering coal to coke ovens, so as to prevent the operator from abusing his control through excessive plugging. The contact finger *R*9 was removed so as to prevent cutting out the resistance step between 9 and *X* on the ninth or last point of the controller.



This condition caused operating delays which could not be permitted.

One remedy which suggested itself was to install limit switches to limit the travel of the nut in both directions on the screw. Owing to the lack of space and also to the hot and dirty location in which the limit switches would have to be installed, it was not considered practicable to use them. Satisfactory operation has been obtained simply by installing more resistance in the motor circuit so that the speed of the motor is reduced. This cuts down the possibility of overtravel.

The resistance supplied with the drum controller on this drive consisted of 20 wire-wound tubes assembled in a box having a total resistance value of 25 ohms. This value was increased to approximately 40 ohms, which was found to give the desired results. The use of so much tube resistance in the operator's cab was objectionable as these boxes are difficult to mount and to repair. Consequently, an entirely new resistor was made up consisting of six standard 500-watt, 115-volt, space heaters. A space heater of this capacity has a resistance of approximately 26.5 ohms and a full-load current rating of 4.35 amp. Using two space heaters in parallel gives sufficient current-carrying capacity and to secure the necessary value of resistance, six units were connected in series-parallel, as shown in *A* of Fig. 4, giving a total resistance of 39.75 ohms. These heaters were bolted into a strap-iron frame and fastened to the wall of the cab.

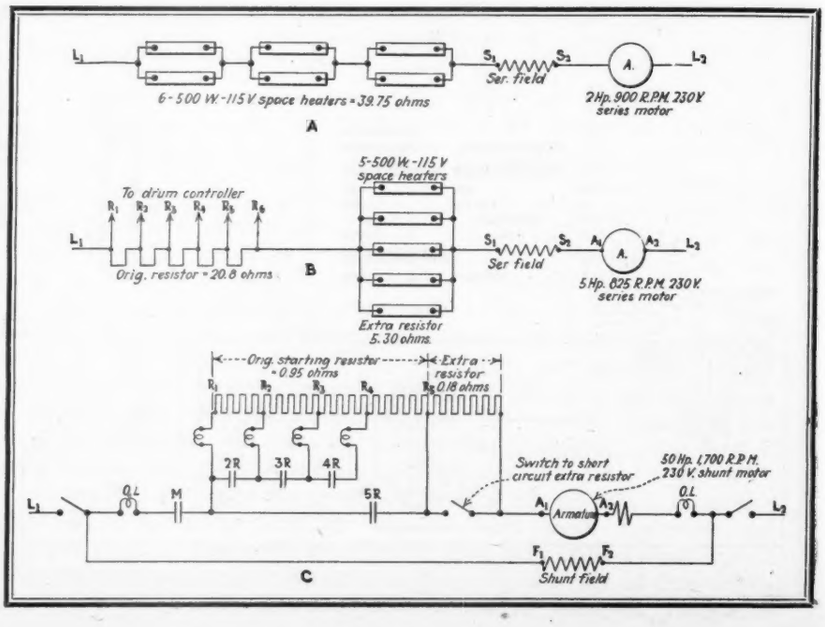
There are quite a number of places where space heaters will be found to work very satisfactorily as resistors when the current handled is not over 15 or 20 amp. On one installation consisting of a 5-hp., 825-r.p.m. series motor driving a pusher door ram, a permanent resistance was installed to prevent overspeeding of the motor. This installation was made up of five 500-watt, 115-volt space heaters connected in parallel as shown in *B* of Fig. 4.

Having shown the improvement that can be made in the operation of some variable-speed motors by the introduction of additional resistance, let us consider a special case involving a constant-speed drive which was improved in the same manner. Three 50-hp., 1,700-r.p.m., 230-volt, shunt-wound, constant-speed motors were installed in a boiler house and were coupled directly to three forced-draft fans. Trouble was experienced with these motors at first through overheating and poor commutation. When a test was made it was found that the line voltage was 250 volts instead of 230 volts. This excess voltage caused an increase in speed of the motors from 1,700 r.p.m. to about 1,840 r.p.m. At this speed the fans were delivering more air than was required and, since the horsepower required by a fan varies directly as the cube of the speed, the motors were working under a continuous overload, thereby causing the overheating and bad commutation previously mentioned. It was not possible to lower the voltage on this circuit without affecting the voltage of the whole plant; so a permanent resistor was designed for use with each motor to cut down the voltage across the motor terminals to 230 volts and bring the speed down to 1,700 r.p.m. This resistance, which has an ohmic value of 0.18 ohm, was built up of standard grids having a continuous current rating of 200 amp. and, therefore, operates at a low temperature which means long life and little maintenance. A knife switch was installed to short-circuit this extra resistance in case of an emergency when extra air might be required through failure of one of the fan motors, in which case the remaining motors could stand an overload for a short time. Since the installation of this resistance, the operation of these motors has been perfect and a considerable saving has been made in brushes, commutator wear, and possible armature rewinding, with the advantage that this equipment requires very little attention from the maintenance men, leaving their time free for other duties. Diagram *C* of Fig. 4 shows the connections of the above fan motors and indicates where the extra resistance was inserted.

A quick method of calculating the amount of resistance required for a given motor is to divide the line voltage by one and a half times the full-load current. Thus, resistance = (line voltage ÷ full load current × $1\frac{1}{2}$). This value of resistance will allow an inrush of less than 150 per cent full-load current, which is permissible in most cases, since the resistance of motor leads, interpole coils, etc., will be included and may reduce the inrush 10 to 20 per cent. If the resistor is installed with an ohmic value calculated as above and taps provided, it is an easy matter in case of necessity to cut out a little resistance after the equipment is put into operation: much more easy, in fact, than to add more resistance. Another advantage is obtained by having a little extra resistance available; in case a grid fails the tap can be changed, thereby putting one of the extra grids into service.

Fig. 4 — On small motors space heaters were used to advantage as resistors.

Diagram *A* shows the resistor arrangement for the door hook motor on a coke pusher. Six space heaters were connected in series-parallel so as to provide a total resistance of 39.75 ohms. Diagram *B* shows how space heaters were connected in series with the armature of a 2-hp. series motor so as to prevent overspeeding. Diagram *C* shows how resistors were used with a 50-hp., 230-volt, fan motor to permit operation on a 250-volt supply without overspeeding and thereby overloading the shunt motor



Facts for Your Transformer Data File

With a few pointers on checking up your own knowledge on the subject

TODAY less attention is given to a transformer serving an industrial plant than any other piece of electrical apparatus after it has been installed. It has no moving parts and, therefore, has no squeaks nor groans to indicate the want of attention, and unless lightning comes along and plays havoc with the windings, the transformer stays on the job in spite of the mistakes or the indifference of the men whose job it is to look after it. As a matter of fact, some transformers that have been on the job for the past ten or fifteen years should be given a permanent vacation in a nearby junk yard. A transformer will never actually wear out, but it will get so old, based on the core losses of newer designs, that the cost of energy to supply these losses will more than justify the purchase of new units on the basis of the possible saving in energy actually consumed in the transformer itself.

Except when used by central station companies, power transformers are often purchased today like sugar and salt, as needed and with few questions asked except the price and the delivery date, and the delivery date will frequently be the deciding factor simply because someone has delayed an investigation of the subject and finds himself forced to buy a pig in a bag because he must have a transformer on a certain date.

It is my purpose on this occasion simply to point out a few things about the selection and purchase of transformers. For instance, when you are called upon to buy a transformer for a particular service, low price and light weight are not a good basis to use. You should know how to determine the following points: (1) The ratio of iron and copper losses that will make the total cost of the transformer losses a minimum. (2) The total cost of the transformer during its estimated life, including its first cost price and the total cost of its losses. Then you should know something about transformer construction in order to purchase designs and sizes that will be suitable for changes and rearrangements that come about as time goes on and operating conditions change.

The bulletins of manufacturers often furnish much good, practical information along these lines and engineering handbooks contain some useful suggestions, but the best source of information is articles published by men who have given serious thought and study to transformer problems. There is one little publication that gathers up these practical articles and reprints them and from this I personally get a lot of practical pointers and think enough of it to carefully file it away for handy reference. This little publication is called "Kuhlman Kurrents" and is issued each month by a transformer manufacturer. If you would like to know how to secure a copy of this publication I will be glad to give you the mailing address, if you will drop me a note asking for it. Then again, there are at least two bulletins issued by The Electric Power Club that every operator should have in his information file. These are known as "Transformer Standards" and "Instructions for the Installation, Operation and Care of Distribution Transformers." These two copies will cost you about 60 cents but once you have them you would not part with them at any price.

These days, if you are going to stay in the electrical game, you must be an "Iser and not a has-been" as Elbert Hubbard used to say. And since I find that industrial plant men know less about transformers than they know about much more intricate electrical equipment, it seems to me a good chance for the energetic young fellows to get into the first ranks of those familiar with this subject as applied to industrial plant work, for you never know when you may be called upon to say you do or you do not know enough about transformers to spend your firm's money and get proper value therefor, or to tell when old units are costing too much money from high core losses to keep them in service.

Practical Pete

INDUSTRIAL ENGINEER
Devoted to the Maintenance and Operation of Electrical and Associated Mechanical Systems in Mills and Factories
G. A. VAN BRUNT, *Managing Editor*

Draw on the Experience of Other Men in Solving Your Problems

IF ONE chooses he can go his own way alone, in so far as his job is concerned, handling it to the best of his ability and asking no questions of anyone. However, unless he is possessed of unusual ability the chances are that he will not accomplish the results or attain the success that could be his if he would avail himself of the knowledge born of experience that other men working along similar lines could give him.

Therein lies the value of technical publications and the various engineering societies and associations, such as the Association of Iron and Steel Electrical Engineers, whose Twenty-second Annual Convention is announced on another page of this issue.

On the one hand, technical publications bring to your desk a written, continuous record of the progress made by other men working in their particular fields. On the other hand, attendance at gatherings of the character indicated above affords an opportunity to meet and discuss with men of wide experience those problems which must be met and solved in every industrial plant. After all, these problems differ, for the most part, in detail rather than in principle.

Apart from the valuable and inspiring friendships that are certain to result, the opportunity of drawing upon a storehouse of knowledge that represents more experience than one could hope to obtain in several lifetimes, should be regarded as a privilege that is not to be taken lightly.

Do Not Let Quick Decisions Get You Into Trouble

SEVERAL serious blunders which were made by a young operating executive, and eventually led to his removal from a position of authority, were said by some of his associates to be due to a lack of engineering knowledge. In expressing this opinion these fellow-workers made the same sort of error that led to the other fellow's downfall—they took a snap judgment without knowing all of the circumstances. As a matter of fact, this young engineer did not lack either training or experience, but when he had to decide several important matters he gave his decisions on the spot, with no apparent study or foresight. Under the circumstances, his decisions were little more than guesses—and it turned out that his guesses were wrong.

Whether his actions were due to a desire to appear more competent than he really was, or whether they were the result of mental laziness that kept him from digging out all of the facts, need not be discussed here. There is no doubt however, that many errors of judgment in engineering matters are the result of snap decisions or guesswork, rather than a real lack of sufficient technical knowledge or experience to solve the problem correctly.

In many cases, when trouble with equipment is traced down it is found to be due to misapplication rather than to any real defect in design or manufacture. Someone who did not take the trouble to determine all of the facts tried to make the equipment do something, or operate under conditions, for which it was not suited, and trouble resulted.

Of itself, the ability to make quick decisions is commendable rather than otherwise, and when it has a sound basis of experience, there is no objection to exercising it. However, when this ability is merely assumed, such decisions are little more than guesses which are just about as likely to be wrong as correct.

How Often Do You Pull and Clean Your Knife Switches?

THAT poor contact, with consequent high resistance, in the jaws of knife switches may be the unsuspected cause of a good deal of trouble was shown by two cases which recently came to light.

In the first instance, one leg of a 1,500-amp., three-pole service switch in a large office building suddenly melted and caused considerable annoyance until the cause of the trouble was located. Upon investigation it was found that the load was in the neighborhood of 600 amp., considerably less than the rated capacity of the switch, which it was then recalled had been heating for some time. Examination of the switch showed that the contact surfaces of the blades and jaws were black and badly pitted from small arcs. So far as could be determined this switch had not been pulled for several years, perhaps not since it was installed. Dirt and the natural tendency of copper to tarnish and corrode had in time increased the resistance of the contact surfaces until serious heating took place, which further aggravated conditions until failure occurred.

In the second case, complaints of low voltage on some of the branch circuits in another large building created a suspicion that the feeders were too small for the load carried. However, checking the size of the feeders against the load showed that there was an ample margin of safety. The trouble was eventually traced to the service switch, which was heating badly and introduced enough resistance into the circuit to cause a decided voltage drop. As in the previous case the contact surfaces were badly discolored and pitted. When the switch was cleaned and put in proper condition there was no further trouble.

The remedy for such conditions is obvious: Pull all knife switches frequently and polish the contact surfaces of both blades and jaws, making sure that the latter grip the blades firmly.

Education in Material Costs Will Help to Prevent Waste

PREVENTING waste of the materials and supplies used by the maintenance and repair departments is oftentimes a rather difficult problem. Comparatively few workmen are deliberately wasteful of the materials they use, and when one such individual is discovered a friendly word of caution may be all that is needed to bring about the needed change of habits.

The carelessness or thoughtlessness that most of us possess to a greater or less degree presents, however, a much more difficult situation. It is carelessness more than anything else that causes a workman to draw out more wire, conduit or whatnot than he needs for the job in hand and leave the excess lying around until it becomes useless, or else quietly consign it to the junk-pile, when no one is looking.

In most cases the real reason for this carelessness or indifference is a combination of ignorance of the cost of materials and failure to realize that these cost money. With a well-stocked storeroom to draw from it is easy, perhaps natural, to adopt the attitude that "there is plenty more where that came from"—an attitude that is fatal to the economical use of material.

Along the same line is the tendency of many workmen to use expensive materials, for example special wire, when cheaper, standard material would be entirely satisfactory. Individually these little wastes may not be very important, but in the course of a year their total may well be enough to increase the cost of maintenance and repair work considerably.

One of the most effective means of combating carelessness of this sort is a campaign of education in the cost of the materials and supplies used. If a workman can be taught to think of these in terms of dollars and cents per foot or per pound, they will assume a new measure of value in his eyes and he will be far less likely to waste them needlessly.

A Squirrel-Cage Motor Takes Advantage of an Easy Master

WHEN laying out an installation of equipment it is usually more economical in the long run to allow a liberal margin of reserve capacity to take care of unexpected overloads and normal growth. Not only will time and money probably be saved later on, but there is the satisfaction of knowing that the present installation will safely handle any likely demands. In the case of most items of equipment found in industrial plants, the possession of a reserve capacity even largely in excess of the present requirements is not of serious consequence. Some capital will be tied up needlessly in heavier equipment than is required, and operating losses of one sort and another may be increased, but that is about all.

Squirrel-cage motors are one of the exceptions to this general rule. This type of motor possesses many desirable features, but one of its weak points is that at loads much below rating the power factor falls off rapidly, particularly in the case of slow-speed motors. If many underloaded squirrel-cage motors are in use in an industrial plant the power factor may easily be reduced to the point where it becomes an expensive and serious problem.

Consequently, when selecting a squirrel-cage motor for a given application, it should be remembered that this type of motor operates at its maximum power factor and efficiency at somewhere near rated load. This means that the power requirements must be known, or determined as accurately as possible. Ordinarily it is not a difficult matter to determine the power required to drive a machine or lineshaft, and the time and effort involved in so doing will be well spent. Naturally, any unusual load conditions must be given due consideration, and good judgment must be used in allowing for probable overloads, but aside from this, an excess of capacity in a squirrel-cage motor should ordinarily be considered as a liability rather than an asset.

A Well-Equipped Electrical Repair Shop Will More Than Pay Its Way

DOES your electrical repair shop consist of a workbench, an armature rewinding stand, a few reels of wire, some rolls of tape, and a can of paint, or is it a small factory equipped to do rebuilding of damaged equipment? Many executives think of the repair shop as a non-producing part of the plant, and consequently slight it when obtaining shop equipment.

Three steel plants that the Editors have recently visited had repair shops that were nothing more than a miscellaneous collection of cast-off machines and junk. As a direct result, the quality of repair work has suffered and a high repair cost has been accepted by the management as an unavoidable necessity.

All three of these plants are now engaged in building modern electrical repair shops, for the electrical superintendents have at last been able to convince their superiors that these are a good investment. Only one shop visited, and which is now completed, contains complete equipment for repairing motors and control equipment and also for doing the machine work that is necessary in this connection. A partial list of the equipment in it includes coil winding equipment, two drill presses, banding lathe, standard lathe, armature press, shaper, dipping tank, modern baking oven, complete electrical storehouse, and even a ball-bearing-equipped overhead traveling crane to serve the shop alone. This shop is as completely equipped as the motor assembly floor of a small motor manufacturer.

The result is that the repaired electrical equipment will be as good as new equipment of the same type obtained from the manufacturer. It is on this basis that modern and complete repair equipment in the repair shop can be justified, and will effect a substantial return on the investment.

Annual Convention of

Association of Iron and Steel Electrical Engineers

which will be held in connection with the Iron and Steel Exposition at Chicago, Ill., June 7 to 11, 1926.

UNUSUAL efforts have been put forth to make the Twenty-second Annual Convention more interesting and a greater success than ever before.

The convention has been planned with the thought of answering the question of what are the accomplishments of the industry, keeping in mind the tendency of the times. From the program shown in the adjoining box it will be seen that the subjects covered are of direct interest to every engineer and executive in the iron and steel industry.

This year's convention will be held at the Hotel Sherman, Chicago, Ill. A new feature, and one which should help to make the convention a greater success, is that all of the convention activities will be under one roof. With the exception of the meetings of the Safety Session, all of the papers and discussions will be presented in the Crystal Room of the hotel. The exhibits of the Iron and Steel Exposition will be held in the Exposition Hall and Ballroom combined, while the social affairs will take place in the Louis XVI Room and the Bal Tabarin of the same hotel.

The Iron and Steel Exposition, more aptly termed the "Million Dollar Engineering Exposition," will be larger and better than ever before. Thirty-five thousand square feet of space will be devoted to displays of manufacturers, showing the latest developments in electrical, mechanical, combustion, and safety equipment devised for steel mill use.

This association, as its name indicates, is an organization of the electrical engineers of the iron and steel industry. In 1907 at a meeting of representative electrical and mechanical engineers to inspect a special exhibit of electrical apparatus for use in steel mills, at one of the plants of a prominent manufacturer, it was suggested that a national organization be formed to promote a closer spirit of co-operation between the engineers of the industry. Since this time rapid strides have been made in the industry, particularly in the application of electrical energy to its power problems. Due to the interchange of thought brought about by this association, electrification of the steel industry has proceeded at a more rapid and successful rate than has the electrification of any other industry. As time went on the Association broadened its activities. In 1912 it founded what is now known as the National Safety Council. At a later date when the waste of heat in steel mills became more generally recognized, a Combustion Division was formed, which was to be devoted to solving the heat and fuel problems of the industry. Last year it was felt that, in the last analysis, safety in the steel mills rested upon the degree of co-operation obtained between the safety man and the engineers who know the inherent characteristics of the machines that must be guarded. With the view of promoting co-operation between these two groups of men, the Safety Division was organized. As a result the Association's activities now enter the fields of electricity, heat, and safety, as applied to the steel mills.

The Association of Iron and Steel Electrical Engineers is the only organization devoting its attention primarily to industrial power problems, and specifically to the application of electrical energy in the iron and steel industry. The same general problems interest and must be solved by men in all other industries and it is for this reason that INDUSTRIAL ENGINEER will report the activities of this convention for its many readers in other industries, as well as those in the steel mills. If it is at all possible we would suggest that you plan to attend this convention. You will receive a royal welcome and be afforded an opportunity of exchanging ideas with men who have met and solved many perplexing industrial problems.

Program for Annual Convention of Association of Iron & Steel Electrical Engineers

MONDAY, JUNE 7

9:00 a.m.—Registration—Mezzanine Floor.

10:00 a.m. — Business Session — Crystal Room.

12.30 p.m. — General Luncheon — Louis XVI Room.

1:30 p.m. — Safety Session — Rules for the Safe Operation of Electric Overhead Traveling Cranes. — Louis XVI Room.

9:00 p.m. — Informal Reception — Louis XVI Room.

TUESDAY, JUNE 8

ELECTRIC TRANSPORTATION DAY

10:00 a.m. — Crystal Room — **Economies of Steel Plant Railroad Electrification**, by O. Needham, General Engineering Dept., and David C. Hershberger, Engineer, Railway Section, Westinghouse Electric & Mfg. Co.

How Electrical Industrial Truck and Tractor Equipment Is Effecting Savings in the Iron and Steel Industry, by H. J. Payne, Electrical Industrial Truck Department, The Society for Electrical Development.

Yard Switching and Mill Transportation, by W. P. Potter, Engineer, Railway Dept., General Electric Co., and G. H. Shapter.

WEDNESDAY, JUNE 9

10.00 a.m.—Crystal Room—**Refractories for Use in Steel Plants**, by M. C. Booze, Senior Fellow, Mellon Institute, Pittsburgh, Pa.

Open Hearth Roof Construction, by W. J. Harper, Combustion Engineer, Donner Steel Company.

Refractories in Steel Plants, by W. H. Kelly, Refractory Engineer, Bethlehem Steel Company.

Coke Ovens, by M. J. Conway, Combustion Engineer, Wheeling Steel Corporation.

Heating Furnaces, by E. W. Trexler, Combustion Engineer, Bethlehem Steel Company.

Gas Producer Operation, by F. E. Leahy, National Tube Co., Pittsburgh, Pa.

Standardized Mill-Type Motors, by A. C. Cummins, Chairman of Standardization Committee.

THURSDAY, JUNE 10

10:00 a.m.—Crystal Room—**Report of Electric Heat Committee**, by W. P. Chandler, Chairman.

Additions to Rolling Mills, Wheeling Steel Corp., Steubenville Plant, by M. J. Conway, Combustion Engineer, Wheeling Steel Corp., Steubenville, Ohio.

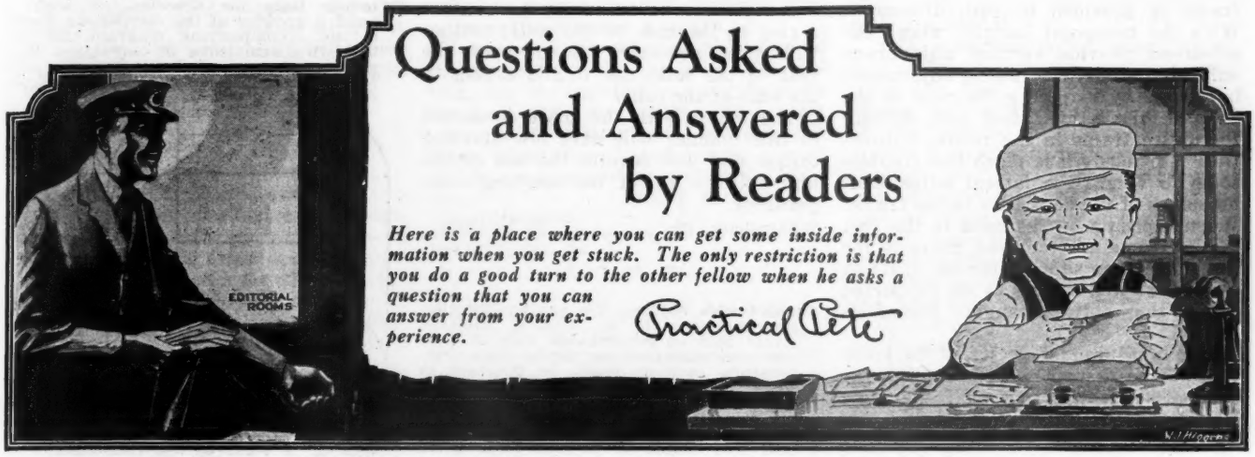
Results of Tests — Four Cylinder Poppet Valve Reversing Uniflow Engine Driving a Blooming Mill, by M. J. Conway.

7:00 p.m.—Formal Dinner Dance—Bal Tabarin.

FRIDAY, JUNE 11

9:00 a.m.—Inspection Trip—Illinois Steel Co., Gary, Ind.

1:00 p.m.—Golf Tournament—Gary Country Club.


EDITORIAL ROOMS
Questions Asked and Answered by Readers
Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.
Practical Pete

Who Can Answer These?

Use of Non-Metallic Gears—I wish that our readers would give me their experience with the so-called non-metallic gears. We have several gear drives which wear rapidly, due to irregular loading, and soon become noisy. If I should use non-metallic gears would I have to use pinions with wider faces, and also have to replace the present gears with others having wider faces? If so, approximately how much wider would the faces have to be?
Des Moines, Iowa. J. F. K.

* * * *

Method of Controlling Brush-Shifting Motor—I should appreciate it very much if some reader would tell me the different and proper ways of controlling a type BTA, General Electric, adjustable-speed, brush-shifting, alternating-current motor. I should like to know what type of control should be used, and any information or explanation of the principles under which this controller works will be greatly appreciated.
Passaic, N. J. H. V.

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Charging Storage Batteries—Will some readers of these columns please inform me how, if possible, I can make up a unit to charge small storage batteries from a 220-volt, direct-current power supply? The storage batteries range from 1 cell (2 volts) to 6 cells (12 volts) in potential and up to 240 amp.-hr. in capacity. Can I charge these batteries from a lamp bank? If so, how many and what size of lamps should I use, and how should they be connected? Any other information that readers can give me along this line will be greatly appreciated.
Chicago, Ill. W. A. B.

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Why Do These Motors Stall?—The motors on two Yale and Towne electric hoists are giving us trouble and I wish someone would tell me how to remedy it. One hoist is of 1-ton capacity and is driven by a 220-volt, three-phase, 60-cycle, six-pole motor. The other hoist is of ½-ton capacity and is also driven by a three-phase, 220-volt, 60-cycle motor. If a load of 200 lb. or more is placed on the hooks the motors will stall, although they seem to run at full speed at no load. This trouble started suddenly. The mechanical part of the hoists has been inspected and appears to be in good condition. Your suggestions will be very welcome.
Iola, Kan. T. R. P.

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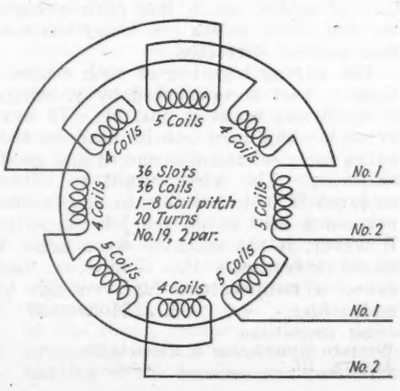
Excessive Wear on Brake Wheels—We use magnet-operated, shoe-type brakes on many of our steel mill auxiliary drives such as manipulators, side guards, screwdowns, crane hoists, and the like. There is excessive wear on the brake wheels and I should like to know how other readers have corrected this trouble. The brake shoes pressing against the wheel are lined with "Thermoid" or similar brake lining and the wheels are machined from 0.20 per cent carbon steel; yet the wheels show distinct grooves and ridging in less than 6 mos. service. Should harder steel be used, or will heat-treating the brake wheels be of benefit? I should like to learn the experience of readers in regard to the latter.
South Chicago, Illinois. W. A. F.

* * * *

Correcting Power Factor—We are planning to electrify the drives in our planing mill, which will require about 600-hp. in 440-volt induction motors, and I estimate that our power factor under average conditions in this mill will be about 70 per cent lagging. I have a 440-kva., 595-amp. 440-volt synchronous motor which I plan to use on a fan in the planing mill that will require about 150 hp. to drive it. This is in addition to the 600-hp. load previously mentioned. I should like to know how much improvement in power factor I can obtain by over-exciting this synchronous motor when it is connected to the same feeder as the rest of the planing mill load and while it is driving the 150-hp. load. I must have a power factor of at least 90 per cent lagging on this feeder and any additional improvement that I can obtain will be very welcome. Can some reader calculate for me or tell me how to determine the resultant power factor if I use the synchronous motor as I have explained above? I should also like to obtain the views of readers as to whether it would be better to use static condensers instead of the synchronous motor for correcting the power factor in this mill.
Bellingham, Wash. E. M. D.

* * * *

Changing Single-Phase Motor for Three-Phase Operation—I have a General Electric, form C, 60-cycle, 220-volt, 1-hp., single-phase, 1,800-r.p.m., motor connected as shown in the accompanying diagram. The armature has 36 slots, and 36 coils, having 20 turns of No. 19 wire wound two in parallel. The coils are arranged in groups of 4 and 5 coils per group as shown. (1) How should this winding be connected for use on a single-phase supply? (2) It is desired to connect the motor and operate it from a three-phase supply. Is it possible to change or reconnect the winding to secure this result? I shall greatly appreciate any information or help that readers can give me about this motor.
Brooklyn, N. Y. W. M.



Answers Received To Questions Asked

What Are the Comparative Advantages of Two-Point and Four-Point Adjustable Hangers?—I am planning on installing an additional section of lineshaft and would like to get the opinions of other readers about whether to use two-point or four-point adjustable hangers. What are the advantages of each from the installation, operation, and maintenance standpoints? Would these advantages be worth the difference in cost? This will be a 1 7/8-in. shaft, 50 ft. long. The present installations are all two-point adjustable hangers. Will other readers tell me what they would use and why?
Indianapolis, Ind. B. K. W.

In response to B. K. W.'s inquiry, I believe that the four-point adjustable hangers are generally accepted as the most desirable. The ease of making minute adjustments, vertically and horizontally, by means of the adjusting screws, is a material advantage from the installation point of view. Also, in case of warpage, shrinkage, or yielding of the structure to which the hangers are fastened, the bearing proper can usually be adjusted without disturbing the mounting of the hanger proper.

The boxes with bearings on all four-point hangers are designed for easy removal, which is an advantage should it become necessary to replace a worn bearing. I would use the four-point adjustable bearing hangers for the following reasons: (1) Saving in time in the initial installation. (2) It is comparatively easy to align the shaft. (3) It is comparatively easy to correct misalignment due to yielding of hangers, supports, and so on. (4) Bearing boxes are readily replaceable. E. H. LAABS.
Engineer,
The Cutler-Hammer Mfg. Co.
Milwaukee, Wisconsin.

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Regarding B. K. W.'s question, the writer would say that in his experience the four-point hanger is practically always preferable to the two-point hanger for line- and countershafting. Nearly all hangers have slots or elongated holes in their feet which allow them to be adjusted sidewise or perpendicularly to the line of the shaft. Setscrews are also provided in the hanger frames for vertical adjustment of the boxes in which the shaft revolves.

The four-point hanger has setscrews in each side of the frame in addition to the top and bottom setscrews; in this way adjustment of the box within the

frame is provided in both directions. With the two-point hanger, where the setscrews provide vertical adjustment only of the box, the lateral adjustment is secured by loosening the nuts on the bolts in the hanger feet and shifting the entire frame in the required direction. Obviously it is much less troublesome to secure the lateral adjustment by means of the setscrews in the frame. When the nuts on the bolts in the feet of the frame are removed, there is for the moment no support for the shaft at that point and it has to be supported while the entire hanger frame is shifted.

It might interest B. K. W. to know that standard steel sections can now be secured for supporting shaft hangers. These sections, used in the same way that wooden stringers have been used, allow any required amount of lateral adjustment for the hangers. In other words, the hanger can be slid along the steel section by means of a sliding bolt seat. These sections are clipped into place in wood, steel or concrete buildings and no holes have to be provided for the feet of the hangers.

Vice-President, P. L. PRYIBIL.
Midwest Steel & Supply Co., Inc.,
New York, N. Y.

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Changing Slip-Ring Motor to Squirrel-Cage Type.—I wish to change the rotor of a wound-rotor induction motor so that it will operate as a squirrel-cage motor. I have rewound the stator for 900 r.p.m. instead of 600 r.p.m. as originally. I have removed the clips from the rotor winding and have the coils ready to short-circuit on themselves. Will it be necessary to change the rotor coil span in order to make the motor operate efficiently? Should I put a ring at each end of the rotor and connect all of the rotor conductors to it, thereby making the winding quite similar to a squirrel-cage winding? Is there a quicker or better way than I have mentioned for converting the wound-rotor winding into a squirrel-cage winding? I would like to obtain the opinion of other readers as to the advisability of making this change in the winding.
Bessemer, Ala. O. S.

The data given do not state whether the rotor is wave or lap wound; however the following discussion will cover either case. If the rotor winding is of the wave-wound type, short-circuit the rings; or if rings are to be removed, short the three leads from the winding, making a permanent connection. Do not disturb the present connections of the individual coils; that is, leave the winding as it was for 600 r.p.m. Then remove the insulation from the top layer of leads for a distance of approximately 2 in. back of the clips. A *bronze* wire band (No. 10 B. & S. gage) is then run over the copper leads thus exposed. This band should be soldered to the leads which it covers, with a tin solder, not half-and-half solder. The points where the connections are made to bottom leads for star leads, or reversing jumpers, should be connected to the top clips.

The object of the bronze wire band is to connect the top and bottom leads together, thus shorting all coils. This is the quickest way of arriving at this result. However, if O. S. has all the clips removed and the leads bent in towards the center of the coil it will be satisfactory to short each coil on itself. The coil pitch in this case will be satisfactory.

It will not be necessary to connect a ring to the ends of the coils; neither will it be necessary to cut open the rear of the coils, nor to add a ring to the rear of the coils.

The motor with the rotor connected in this manner will have low starting torque and will require the use of the high-voltage tap of the starting compensator.

Wilkinsburg, Pa. A. C. ROE.

* * * *

Trouble with Solder.—We are having considerable trouble in making soldered joints hold on rectangular wire in coils that are subjected to rather high temperature, such as might be the case in series field coils and brake series coils. We have tried an 80 lead—20 tin solder, but it melts due to the excessive heat. Can our readers suggest any methods that will enable us to join these wires together in a manner that will stand rather high temperature? I shall be very much indebted to any reader who can give me some help in this matter.
Norton, Va. W. H.

In regard to W. H.'s question, I believe he will find brazing the best process for connecting two ends of wires together for use where there is excessive heat. Take a piece of hard carbon and file a slot large enough to take the size of wire to be used. Clean the wire thoroughly and space the ends ¼ in. apart in the carbon slot. A welding torch with the smallest tip available is best for welding so small a joint, but a gasoline blow torch can be used if it throws a large flame.

When the joint is at a good red heat apply Brazo fluz which is manufactured by the Oxweld Acetylene Co., Long Island City, N. Y. After applying this flux very freely, add enough spelter, a brass alloy, to fill the ¼-in. gap between the wires and hold the torch flame on this joint until the spelter runs freely. Allow the soldered ends to cool slowly in the air but do not apply water as it will make the brazed joint brittle.

Where a joint of this type is used in a coil try and cut the wire so it will not make a bend at the joint. After the joint has cooled file it down to the size of the wire. From my experience a splice of this kind has always made an ideal connection. C. L. PHELPS.

Electrical Dept.
Illinois Central Railroad Co.,
Centralia, Ill.

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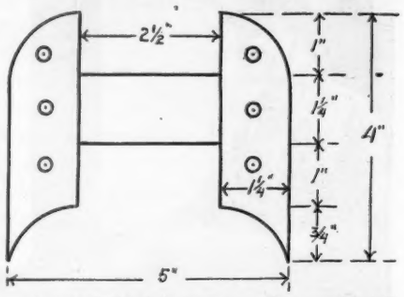
Referring to W. H.'s question, the melting point of an 80 lead—20 tin solder is high enough for most purposes. It seems to me that something else must be wrong to melt this composition of solder which has such a high melting point, unless the solder has not been applied correctly.

The joining together of such connections is best accomplished by riveting, if conditions make it possible. In any event binding wire can be used on the splice for mechanical strength and good soldering. The wires might be silver soldered if it is possible to secure the necessary heat to do the job properly. However, if the machine were mine, I would investigate the conditions that cause a temperature high enough to melt solder. E. J. MORRISSEY.

Chief Electrician,
Western United Gas & Electric Co.,
Aurora, Ill.

Winding Data for Growler.—I wish to build a growler of the dimensions shown in the accompanying diagram, for use in testing armatures in our shop. It is my intention to wind this growler with No. 12 double-cotton-covered magnet



wire and I wish some reader would tell me the number of turns of wire to use and also the depth of laminations required. I want to use this growler on 110-volt alternating current. Any information that readers can give me about making up this growler will be greatly appreciated. J. M. M.
Hattiesburg, Miss.

In reply to the question by J. M. M. regarding the size of wire and number of turns to use on a growler for armature testing, the following may be useful.

The dimensions of the growler which I recommend are nearly twice the size of the one specified by J. M. M., but the principle of operation is the same. The width 5 in. should be 9 in.; the thickness of the core, 1¼ in., should be 2½ in.; the coil space of 2½ in. should be 4 in.; the height, 4 in., should be 7 in.; and the length, not given, should be 6 in.

This growler is wound with 60 turns of No. 6 d.c.c. magnet wire. I think if J. M. M. will stack the laminations about 4 in. thick and use 100 to 120 turns of No. 12 d.c.c. wire, he will obtain satisfactory results. An excellent book recently written covering this subject and many other handy repair shop "kinks" is entitled, "Rewinding Small Motors," by Braymer and Roe.

Chief Electrician, LEE F. DANN.
Donnacona Paper Co., Ltd.,
Donnacona, Que., Can.

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In reply to J. M. M.'s question, I would suggest that he use a larger core than the one shown in his diagram. Instead of the width of 5 in., I would recommend using a width of 10½ in.; make the height 7¼ in., and the thickness of the polepieces 1¼ in. The dimension of 2½ in. shown on his sketch will then become 4½ in. and the length of the core, which is not given, should be 5 in.

This core should be built of thin sheets of iron and held together by ¼-in. brass plates and brass bolts. The bolts in these plates should be countersunk and riveted over after the plates have been tightly drawn together by a clamp or vise. The core laminations can be drawn up tightly by bolts in four of the five holes which are equally spaced; the clamp may be applied near the fifth hole when putting in the first rivet. Then the bolts may be taken out one at a time when putting in the other rivets.

This core should be wound with 180 turns of No. 10 d.c.c. magnet wire for 60-cycle, 220-volt service; for 60-cycle, 110-volt service use 90 turns of No. 7

B. & S. gage, d.c.c. magnet wire. I would advise J. M. M. not to wind this coil with No. 12 wire, as it will prove to be too small to obtain good results.

HARRY J. ACHEE.
Chief City Electrician,
Woodward, Okla.

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In reply to J. M. M., judging from the size of iron specified and voltage, I assume that this growler is to be used only on small armatures.

I have a growler approximately the same size as the one which J. M. M. shows in his sketch. The only difference is that the height is 5 in. instead of 4 in. and the thickness is 1½ in. instead of 1¼ in. This growler has 160 turns of No. 15 wire and is used on 220 volts. The coil is wound in two sections in order to adapt it for operation on either 110 or 220 volts. At times the two coils are used in parallel on 220 volts, if it is desired to heat a coil up quickly.

If J. M. M. will wind his growler with 70 turns of No. 12 wire, I am sure it will be found quite satisfactory for general use. When using a winding that contains larger wire and less turns, it will be found that when testing armatures having fine wire, the induced current may be heavy enough to burn the armature winding open before the short can be located.

I also have a larger growler wound with two coils, one on each leg, each wound with 50 turns of two No. 6 wires in hand or a total of 100 turns. The dimensions of this growler are 12 in. in width, corresponding to the 5 in. on the diagram of J. M. M., and 12 in. in height instead of 4 in., with a thickness of 4 in., instead of the 1¼ in. shown. When this winding is used across 220 volts to test a 5-hp. armature, it draws 102 amp. from the line. The larger the armature under test, the smaller the amount of current taken from the line.

NICHOLAS J. WEISS.
West New York, N. J.

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Is Hard-Drawn or Cast Copper the Better Material for Commutators?—I would like to find out the difference in operating characteristics, if any, between commutators made from hard-drawn copper and from cast copper. In the advertising literature of many of the large manufacturers of motors and generators, commutators are frequently described as being made of hard-drawn copper. Some repair shops furnish commutators made from cast copper. Which material wears the longer? Which material will polish better under the brushes? Does the sand in the cast copper cause eating away of the mica segments between the bars? Would the use of cast copper segments cause excessive heating of a generator or motor? I shall appreciate any information or comments that readers can give me regarding their experience with either type of material.

Cleveland Heights, Ohio. C. B. K.

Replying to the question by C. B. K., asking whether hard drawn copper or cast copper is the better material to use for commutators, I would say that a few years ago I had charge of a small, direct-current generating station in which the commutators were made of cast copper. These commutators were a continual source of trouble, as there were soft and hard places in them which resulted in very uneven wear. By the time the harder side obtained a polish, the softer side would be worn down to the mica, which resulted in having to turn down the commutators about once a month.

I do not know whether the sand in the copper was the cause of mica pitting, but we had to clean out between the bars every day or so. These cast copper commutators were replaced with some made from hard-drawn copper, which are now giving perfect satisfaction.

PHILIP M. EMIGH.
Chief Engineer,
Mountain Water Supply Co.,
Indian Creek, Pa.

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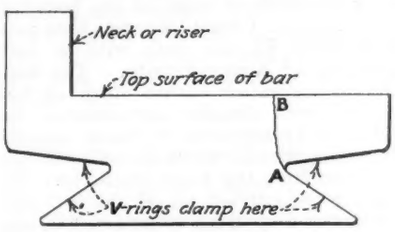
Replying to the question by C. B. K., I want to say that my experience over a period of 25 years has proved to me that the best material is the cheapest in the long run. The following statements are made from a careful investigation of commutator material.

There is only one thing that can be truthfully said in favor of a cast-copper commutator, and that is, the price



Cast copper segments are subject to breakage at points A-B.

is cheaper than for a hard-drawn copper bar commutator, especially where the commutator has a high solid riser. A cast-copper commutator will not take on as good a polish as the hard-drawn commutator, will not wear as long, and will "pit" more. Use of cast copper segments causes the mica segments to be eaten away sooner and in many cases will break at the points *A-B* as shown in the accompanying diagram. If the armature has to be rewound, a cast bar with a solid-type riser will break off at the projections next to the wires in the commutator slot more often than a hard-drawn bar.

Norton, Va. WILLIAM HANKS.

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Replying to C. B. K.'s question as to the comparative qualities of cast and hard-drawn copper commutator bars, I would say from my own experience with both, that the hard-drawn material is more satisfactory. Uniformity of material throughout the bar is a necessity and with cast copper this quality is hard to obtain. The hard-drawn bar, on the other hand, is inherently the same all the way through and without holes or spongy spots.

The correct bevel or taper of the sides of the bar is hard to obtain with castings, but the use of dies or rolls for producing the hard-drawn bars makes it easy to hold this shape to close limits and facilitates the assembly of the bars in the commutator.

In regard to heating, there is little difference between the two bars, unless the cast bar shows sand or shrink holes at the brush contact surface. In this event, the contact area being decreased heating of the brushes and commutator will occur unless the proportions of both are liberal.

Both materials polish about equally well under proper commutating conditions and both wear evenly unless a spongy section shows up in some part of the cast bar. This possibility is always present with cast bars and when through wear a sand hole or a spongy part is exposed on the contact surface, trouble begins. If a defective spot occurs near the edge of a bar, the mica may break down due to the accumulation of carbon dust and grease in the sand hole.

Drop-forged bars come nearer to the hard-drawn material in desirability than do the ordinary cast bars. However, the tool charge on these is much higher than on the hard-drawn bar, so that for the repair shop, at least, the hard-drawn bar has another advantage. The tool charge on hard-drawn bars was formerly very high and this gave the cast bar a decided advantage, but with improved methods, this handicap has been removed and the cast bar has practically no quality to recommend its use.

Ass't. Chief Engineer, J. M. WALSH.
Guerney Elevator Co.,
New York, N. Y.

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In reply to C. B. K.'s question, he will find drop-forged copper the best to use for making commutators. Commutators are made of three different grades of copper: that is, drop-forged, cold-rolled and cast. Cast copper is of very low grade and is likely to be porous, which makes it difficult to polish so as to obtain a good smooth surface. Its wearing qualities are from 75 to 90 per cent of those of hard-drawn copper. Cast copper should be used only when hard-drawn copper is not available. Hard-drawn copper is the longest wearing and will also polish better, therefore, cutting down brush expense.

I do not find that sand in cast copper has any effect on the mica. It has been proven that the pores in cast copper fill with carbon dust off the brushes and cause heating. If the pores are close to the mica, this heating breaks down the mica and causes trouble.

Electrical Dept., C. J. PHELPS.
Illinois Central Railroad,
Centralia, Ill.

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In reply to C. B. K.'s question, it has been my experience that the operating man who pays attention to the advice of the manufacturer has the least trouble and expense. The manufacturer's organization and integrity are founded on years of experience and at a considerable cost in trying to put out the best product possible; so when the manufacturer advises the use of good copper for commutators, he speaks from a background of experience in manufacturing and repairing them.

Rolled copper has all of the good advantages in comparison with cast copper. Cast copper has about 80 per cent of the conductivity of rolled copper and will not wear as long. Cast copper also has impurities, blowholes and other defects that may be minute enough to be invisible but are detrimental to the commutator. I would not blame the eating away of mica directly to the sand, as it is more likely due to

the poor conductivity of the cast copper. This poor conductivity is the equivalent of overloading a commutator and causing heating, sparking and other troubles. When one considers that cast copper has 20 per cent less conductivity, the heating becomes quite an item, particularly when a commutator is designed closely. Good commutation cannot be expected from a poorly-designed commutator or one repaired with inferior material. Accordingly, I would strongly advise using the highest grade of copper, which should be put together in the best possible manner and should have extremely good care in operation, because a commutator costs money to repair. E. J. MORRISSEY.

Chief Electrician,
Western United Gas & Electric Co.,
Aurora, Ill.

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In reply to C. B. K.'s question, asking whether it is better to use cast or hard-drawn copper for commutator segments, I would say from my experience that hard-drawn copper is superior in many ways. It has less impurities than cast copper and consequently has a lower resistance, which results in less heating. I never have seen a cast commutator that could compare with a hard-drawn commutator in regard to polish and color after it had seen six months of service.

We have obtained commutators from four different manufacturers and, with the exception of one, they all make cast bars because they are cheaper. The repair shop is after the cheapest material to meet competition. This is the only logical reason for using it, according to my opinion.

Another point I have against cast copper commutators is that very often blow-holes are found after machining them in the lathe. When an assembled commutator is bored out, the end chips will invariably dig into the mica. It is then necessary to obtain a pick and dig them all out. If one chip should push its way out of sight, there will be a short-circuit when the commutator is heated and pressed together.

I might add that if the commutator is of ample size the heating will be of little consequence. I do not think that enough sand will be found in cast bars to cause any trouble in the way of short-circuits. NICHOLAS J. WEISS.

West Newark, N. J.

* * * *

Selecting Belts for Oily Work.—We have had considerable trouble with the drives in the screw machine department of our plant due to the belts getting soaked with oil. We have been using leather belts. I would like to know whether there is any treatment I can give these belts to make them oilproof or if there is any belt which is not affected by the oil. Also, how do other men with a similar problem remove the oil from the used belts and put them in condition for service again?

Chicago, Ill. G. F. H.

In line with my experience, G. F. H. may obtain good results if he will remove the oily belt from the machine, and first scrape off all of the oil and dirt that he can and then wash the belt thoroughly in gasoline until all oil is removed. He should not soak the belt too long unless he has facilities for recementing any joints or laps which may be loosened by the gasoline.

After the belts are dry and free from gasoline he should apply two coats of castor oil with a brush on the pulley side of the belt; after most of the castor oil is absorbed the belt is ready for service.

I do not know of any oilproof treatment for belts. From my experience, leather belts give the best service for a drive of this kind, with the exception of a chain drive on direct-connected screw-machines.

Marietta, Ohio. E. L. WAY.

* * * *

There is to my knowledge no belt made which will stand up and give anything like efficient and continued service under the oily conditions too often found on screw machine work. Naturally, the more the belts can be protected from the oil spray the better the service that can be secured. As it is impossible to keep oil entirely *off* from these belts, the only thing to do is to keep it *out* of the belts, because leather belts are without question the best for this service. I would suggest that you thoroughly fill the belt with a belt dressing of heavy density. The belt cannot thereafter absorb much oil because it will already have absorbed its fill of a preservative material heavier than the oil and which the oil will not displace from the fibers of the belt. By wiping the surface oil off the belt day by day and applying a little belt dressing, good results can be secured.

To remove the oil with which the belt is saturated, the belt can be immersed in gasoline for 48 hr. and then hung up to dry, or in place of the gasoline a non-flammable belt cleaner, such as made by belt dressing manufacturers, can be used. WM. D. YOUNG.

Cling Surface Company,
Buffalo, N. Y.

* * * *

Armature Bands Overheat.—Five bands are used on a 220-volt, d. c. armature with which we are having trouble. The armature coils slope very sharply and to prevent the outside bands from slipping off the ends of the armature, the winder soldered copper strips across the bands so as to tie them together. Six ⅜-in. strips were placed parallel to the coils and spaced at equal distances around the armature. The bands as well as the copper strips are well insulated from the armature winding, but the bands and particularly the copper strips become very hot, presumably from some induced current. I would like to know what causes this heating and how it may be prevented. If it is induced current that causes the heating please explain what causes this current. Is there any way in which I can tie these bands together that will not cause the heating referred to?

Oelwein, Ia. L. T. M.

L. T. M. asks in a recent issue for an explanation of the heating of armature bands and tie strips. The writer encountered this trouble some time ago when one of our armature winders did the same thing that L. T. M. describes.

The heating is caused by current which is generated in the copper strips, not in the bands. The strips, being parallel to the coils, will cut the magnetic field in the same way that the armature coils cut the flux. This cutting of flux generates an electromotive force in the strips, and since the strips are soldered at each end to the bands, the electromotive force or voltage causes a current to flow through the strip to one band and along the band to the next strip, back to the other band, and along it to the first strip. This is a closed path of low resistance and the current set up may be comparatively large.

It may not be necessary to tell L. T. M. that bands should not be put on a sloping surface where they are liable to slip off. But if it is necessary in this particular case to use tie strips, the trouble could be overcome by insulating the strips from the bands with mica, in order to prevent the flow of current.

Another method would be to place the tie strips in such a way that there would be an equal number of strips under similar field poles and no strips under the poles of opposite polarity. By this means electromotive forces of equal value would oppose each other and no current would flow.

R. B. TURNER.

Manager and Electrical Engineer,
Johnson-Turner Elect. Repair & Eng. Co.,
Walkerville, Ontario, Can.

* * * *

Answering the question by L. T. M., I have had the same experience that he described. His armature has five bands, two of which are not on the core and three which are core bands. Six anchor strips are provided to prevent sliding of the end bands. The heating is caused by induced current in which the anchor strips form the circuit.

This may be corrected by cutting off all six of the anchor strips on each side of the center core band, leaving the one core band on each side to support the end bands.

In my case I had four of these anchor strips, each being of different width. After running the motor for three minutes, the strips smoked, and the smallest one fused apart. After cutting all the anchor strips open on each side of the center band the bands were all right. I hope this procedure will cure the trouble in your case, also.

Chicago, Ill. CHARLES REICHENBACH.

* * * *

Replying to the question of L. T. M. in reference to armature band heating, the method of connecting the bands that is used by L. T. M. gives a short-circuited winding revolving in a field and will cause heating for the same reason that a short-circuited coil in the armature will heat, the difference being only in degree. There is a field due to leakage, much weaker than the field in the air gap, in which the copper strips are rotating and cutting the flux. This sets up an alternating electromotive-force in the strips, and the bands complete the short-circuit.

To prevent such heating, the strips must be so insulated that current cannot pass through them from one band to the other. L. T. M. could prevent the heating if he substituted for the copper strips some insulating material such as cord, tape or canvas. The band itself does not generate a voltage in the direction of rotation, but it does generate an alternating voltage in the direction of the shaft; hence its width should not be excessive or it will heat itself, just as the present arrangement heats. E. D. CARTER.

Engineer,
The Baylis Co.,
Bloomfield, N. J.

Electrical Service

around the works

For this section short articles describing ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing, and emergency or special installations.

Removing Overload From Motors Increased Production

IN SOME plants, motors are overloaded to increase production, but the reverse procedure will frequently obtain the same results, as was the case in a plant making armor-plate sections for battle tanks during the war.

The hard, carbon-steel plates, after being cut to the required size and angle by acetylene torches, were ground smooth at the edges on automatic planer knife grinders. The plates were bolted to a carriage on the machine which oscillated them back and forth across the edge of a 36-in. by 2-in. emery wheel. An automatic feed, which was set by adjustment to suit the size and type of plate, moved the material into the wheel as the grinding proceeded.

Each grinder was individually driven by a 5-hp., 1,750-r.p.m., three-phase, 220-volt, squirrel-cage induction motor mounted on the machine, through a belt drive on pulleys with 3-ft. centers. This alone was very poor design, since the belt had to be kept very tight to prevent slippage. A chain or link belt drive should have been used to obtain good results, as the belt tension alone, driving the 36-in. emery wheel at 900 r.p.m. was a good load on the motor. Considerable trouble was encountered with the motors running hot and sluggish, although the electrician in charge could find nothing abnormal, electrically or mechanically. The starting compensators were carefully examined and tested, but it was soon proved that they were not the cause of the trouble. All of the motors were acting similarly, which brought up the subject of low voltage, or poor power factor, but tests proved that these were normal.

At the time, I was in charge of erecting some new boards and lines in the plant for a construction company. Upon the resignation of the chief electrician, I accepted the position and set out to clear up the trouble. A close survey of the machines showed that the plates were being fed into the wheels too fast, and that a larger cut was being taken, to speed up production, than the grinders could handle. Further examination showed that the emery wheels were not being trimmed oftener than once every few days; in fact, a trimmer was difficult to find. The most troublesome machine was used for experimenting in search of the trouble.

To remove the overload, the grinding wheel was trimmed, the feed reduced to normal and the belt tension decreased. As a result, more plates were ground in less time than formerly and the motor cooled off while running all day without a stop. By testing this machine for a few days, it was found best to trim the wheel slightly after three large plates or five of the smaller plates had been ground. Trimming of the wheels and a slower feed were then started on all of the machines, which increased production from 1 to 3 plates per machine per day, and the motor trouble ended.

Overloading a machine is seldom, if ever, an economical method of increasing production. CARL G. HOWARD.

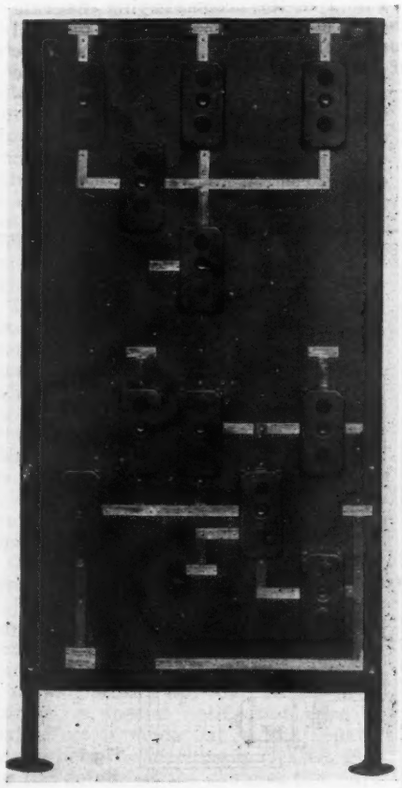
Chicago, Ill.

Panel for Remote Control of Steam Lines

A NOVEL control panel for the remote control of several high- and low-pressure steam lines is shown in the illustration. This panel was designed by the General Electric Co., for the Chapman Valve Co.

The imitation buses represent steam lines, which are identified by the nameplates.

Red indicating lamps above and below each push button show which valves are open.



The imitation buses on the panel are made of polished copper, and represent steam lines. The nameplates are engraved with the size of pipe to a particular boiler, size of pipe to a certain turbine unit, or the location of the valves. The push-button stations are used only to close valves, each being in parallel with the closing button of another push-button station located at some distance from this panel. The "open" control is located at the remote push-button station. As will be noted from the illustration, a red indicating light is placed above and below each push button.

In the lower right-hand corner of the panel there are three push-button stations. The upper button controls the valve on a high-pressure steam line feeding a unit; the lowest button controls the valve on a low-pressure steam line to the same unit, while the middle button is a master which can close either of the other two valves. As the two valves in question are on steam lines of different pressure, both cannot be open at the same time; one must always be closed. The master push-button, when depressed, will close the open valve, no matter which one it is.

By noting which of the red indicating lamps are lighted, it is possible to trace any open steam lines from the boiler to the turbine unit.

Motor Grounded by Carelessness in Reversing Rotor

SOME months ago, I was called to a small commercial establishment to find out why a motor was smoking. After operating the motor a few minutes, it began to warm up and had to be shut down. The bearings were tried by prying on the shaft with a screw driver inserted in the bearing opening of the end bell. The bearings checked all right; so the rotor was then examined, but it did not show any opens or become warm like the stator. I then asked one of the workmen nearby if any one had worked on the motor recently; he replied that the millwright had changed the pulley to the opposite end of the motor, by reversing the rotor and end bells.

This proved to be the information needed, because the rear end bell was not designed to fit the front end, which was arranged so that the frame projected further from the stator laminations. Accordingly, when the rear end bell was changed to the front where the winding connections and stubs were, it

was too short. This caused the stubs of several coils to be shorted, and also grounded because the motor frame was grounded.

In order to clear up the trouble, the damaged coils were repaired, after which the stubs were bent in toward the rotor all the way around the stator and a $\frac{1}{32}$-in. fiber ring was cut and placed over the end of the winding.

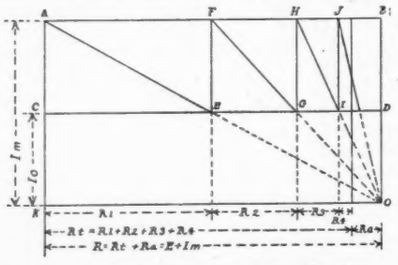
This motor was a 5-hp., three-phase machine of old design. Practically no recently designed motors have these peculiarities. However, this trouble calls attention to the fact that if any changes are contemplated in motor arrangement or if any simple motor troubles occur, it is best to call in the electrician.

Birmingham, Ala. GRADY H. EMERSON.

Graphic Method of Computing Starting Resistance for D. C. Motors

IN DETERMINING the amount of starting resistance required on each step of the starting rheostat, a convenient and simple graphical method such as described in the accompanying diagram will be found very useful.

The maximum current which should flow on the first step of the starter



Use of a diagram like this will simplify the work of calculating the starting resistance for d.c. motors

should be only sufficient to start the motor. If the starting current is over 20 amp., the first step should allow 20 amp. to flow, the second 40 amp. and so on until the motor starts. Thereafter, the back emf. of the machine gradually increases and the necessary series resistance is decreased. A gradual cutting out of starting resistance is required to attain perfectly uniform acceleration. This is possible with liquid starters, but with wire rheostats, the number of contacts is limited between the range of 6 to 12 for small and medium sizes. The resistance between each contact is chosen so that on moving from one contact to the next one, the current does not rise above a predetermined limit depending upon the design and construction of the motor.

The armature resistance R_a can always be measured according to Ohm's law, $I = E \div R$. Substituting the maximum allowable current for starting I_m for I, one can compute the total resistance R of the circuit, which is equal to the armature resistance R_a plus the rheostat resistance R_t. The total amount of resistance necessary in the rheostat will be $R_t = R - R_a$.

The graphical layout is made as follows: R_a and R_t are measured according to a convenient scale on the horizontal axis KO, I_m and I_o, the maximum and minimum allowable starting current respectively, are represented similarly on the vertical axis. The current which would have to be uniformly maintained to get the desired uniform acceleration would be $(I_m + I_o) \div 2$. Draw the rectangles $KODC$ and $CDBA$ as shown. Draw the diagonal OA, and from the point of intersection E on line CD, drop EF perpendicular to AB. Draw line OF and from the intersection point G drop GH perpendicular to AB, and so on. The perpendiculars extended in each case intersect line KO and give the amount of resistance, R_1, R_2, R_3, R_4, that should be inserted between starter contacts. *1* and *2*, *2* and *3*, *3* and *4*, and so on, according to the scale previously chosen. These values are also proportional to the time that the rheostat arm should be held on the respective contacts. The potential difference between adjacent contacts should never exceed 30 to 35 volts.

PIERRE VAN HERK.

Bressoux, Liege, Belgium.

Drum Controller for Slip-Ring Motor Rearranged for Squirrel-Cage Motor

IN MAKING some changes at our plant it was necessary to install a squirrel-cage motor for which we did not have a controller or starter. In looking through our spare equipment a drum controller for a wound-rotor, induction motor was found, which we thought would be suitable, provided we could change it from the secondary-resistance type to the primary-resistance type. The manner in which this was done is interesting.

Fig. 1 in the accompanying diagram shows the arrangement of the original controller, with three sections *a*, *b*, *c* of the short-circuiting segments; these sections are cast in two halves and split vertically. In changing the controller we arranged it as shown in Fig 2. It will be seen that section *c* has been removed and sections *a* and *b* separated by cutting the casting. Sections *a* and *b* are insulated from each other by mica or fiber washers and connected to the reversing segments by the leads *m* and *n*, as shown.

This arrangement put the resistance in the stator side of the motor circuit and thus made the controller suitable for primary-resistance starting of the squirrel-cage motor. It will be noticed that line L_1 in Fig. 2 is not opened with the controller in the "off" position; therefore, the motor has one line lead always connected to the supply. A line switch should be provided to disconnect the power supply from the controller, or two additional segments and fingers could be added to the controller so that line L_1 could be disconnected when the controller is in the "off" position.

W. L. STEVENS.

Westminster, B. C., Can.

The connections of the controller were changed as shown below.

Fig. 1 shows the original connections of the controller. For use with a squirrel-cage motor, the connections were altered as indicated in Fig. 2.

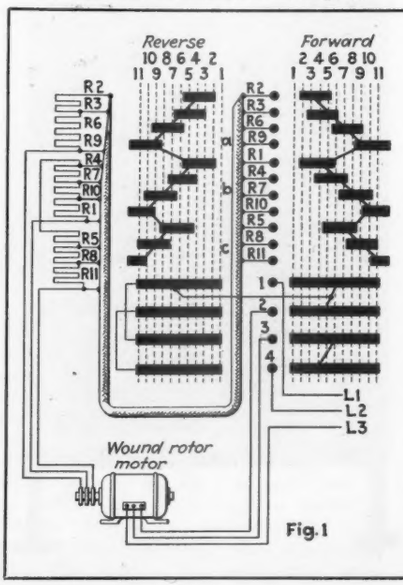


Fig. 1

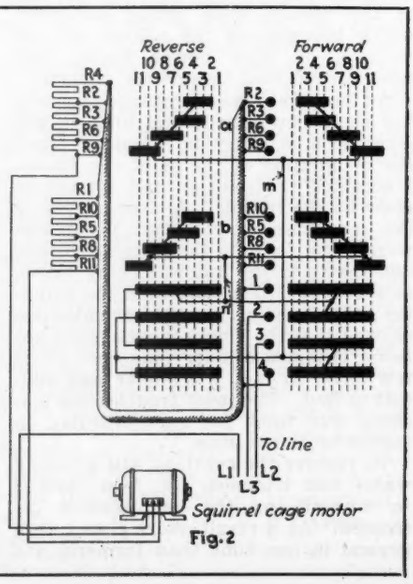
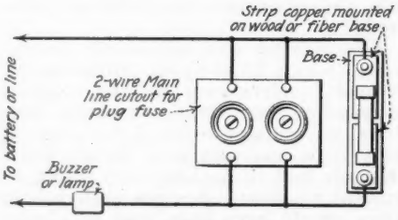


Fig. 2

Simple Testing Block for Plug and Cartridge Fuses

WHEREVER fuses are used in any quantity some convenient, yet inexpensive, device is needed for testing them out. Otherwise, considerable time



A two-wire cutout is connected across a source of supply, for testing plug fuses.

Cartridge fuses are tested by touching the ends to two copper strips mounted on a fiber base. A lamp or buzzer may be used as an indicator.

can be wasted and much inconvenience caused by trying out several fuses in a circuit before one is found that is

suitable for use. Oftentimes carelessness in replacing bad fuses with some that have not been tested is responsible for a hurry-up call for an electrician.

The fuse-testing block shown in the accompanying sketch is very simple to make. It consists of a two-wire main line cutout for testing plug fuses, the screw shells being slit down the sides so that the fuses can be slipped in easily, and two strips of copper mounted on a fiber strip of the size required for testing cartridge fuses. A buzzer or lamp is connected in the circuit as shown to indicate whether or not a fuse is blown. The source of current supply is connected to the binding posts.

This device mounted on a test board within handy reach will be found very useful and satisfactory.

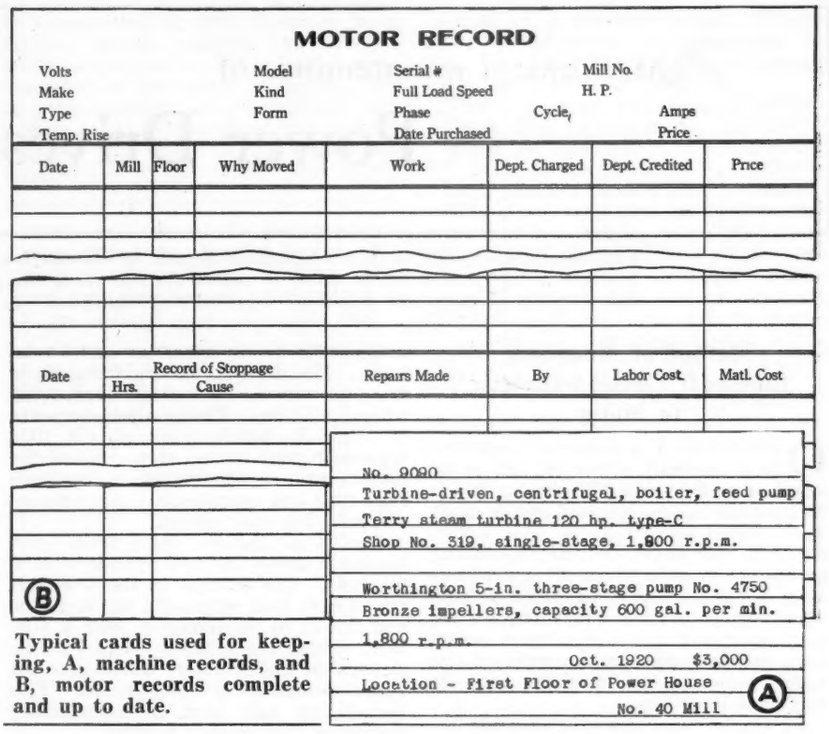
NATHANIEL W. BLANCHARD.
Inwood, Long Island, N. Y.

Handy System for Keeping Service Records of All Machines in the Plant

IN EVERY industrial plant of considerable size where there are many machines of various kinds, the task of keeping a service record of each machine's history, present location, and so on, is a difficult one. As a matter of fact, many plants do not keep such records, or if they do keep them, these fall far short of giving the information required. The following gives the details of a system used in a large textile plant where 15,000 machines including motors are in active use; yet the complete history of specifications, date of purchase, cost price, present and past locations are all available at a moment's notice. The value of such a system of records in case an inventory is desired of the plant equipment is not hard to realize.

Every machine and motor in the plant, whether old or new, is given a number. A brass plate about ⅛ in. wide and of the necessary length, stamped with black enamel figures, is fastened to some prominent part of the machine with escutcheon pins. The No. 44 special hardened drive pin, ¼ in. long, made by the Parker Supply Co. of Springfield, Mass., is excellent for this purpose. This pin has a steep thread cut on its surface and as it is driven into the previously drilled hole, the threaded portion cuts a corresponding groove in the metal, so that the pin will not become loose. If plain escutcheon pins are used they are very likely to come out, allowing the number plates to fall off and the identity of the machine to be lost. If the machine or motor has a manufacturer's nameplate, the plant number plate should be placed adjacent to it.

A 3-in. by 5-in. white ruled card is used for entering the number of the machine, the name of the equipment, the name of the firm from which the machine was purchased, the manufacturer's name, the date of purchase, cost price, location of machine, and so on. If the machine has a shop or manufacturer's number, that also is entered on the card, since it is an important feature in ordering repair parts. In the accompanying illustration *A* shows a typical card used for a centrifugal, turbine-driven, boiler feed pump.



Typical cards used for keeping, A, machine records, and B, motor records complete and up to date.

If a machine is broken up and scrapped the words "Broken Up" with the date are entered on the card. A blue card of the same size as the white one is then filled out with the same data that appeared on the original white card, the white card is taken from the active file and the blue card is put in its place. The white card is then placed in a separate file marked "Machines Broken Up." If a machine is sold to an outside party the same procedure is followed except that a salmon-colored card is used, and the white card is placed in a file marked "Machines Sold." If a machine is not sold or broken up but is simply taken out of active service and placed in storage, a manila-colored card is used and the white card is placed in a "Machines in Storage" file. If the machine is moved to another part of the plant, but is still kept in active use, then the new location is entered on the white card and the card still remains in its original file.

Thus at all times the active file will show first by the white cards the equipment in use, by the blue cards equipment discarded for all time, by the salmon-colored cards equipment sold and by the manila cards equipment in storage. On the other hand, the files "Machines Broken Up" and so on will show in respective groups the disposal of all equipment. In these latter files the white cards are also arranged alphabetically.

One complete set of these files with cards is kept in the office of the Mechanical Superintendent, one in the General Superintendent's office, and one in the Accounting Department where the inventories are made up. If a machine is moved, broken up, sold, or placed in storage, a special notification card to that effect is made out in the department where the machine is located, giving the details of the change; this card is sent to the Mechanical Superintendent's office. The necessary changes in the file are made there by the file clerk, and he advises the clerks in the other departments where there are similar files so that they also can make the changes. The files, therefore, show at all times the complete history of all equipment from the time the system was begun. This information will be found invaluable in many ways, but particularly when taking inventory.

In *B* of the illustration is shown a card used in the same plant for keeping a complete record of the electric motors. In a mill where there are several thousand motors, if some system is not used it is impossible to keep track of the repairs and troubles that arise. Such a motor record as is contained on this card will be of great value in showing up weak points in the manufacture, design, or maintenance of the equipment. This card measures 8½ in. by 11 in. At the top of the card is entered the same data as is on the corresponding 3-in. by 5-in. card previously described. In addition, the card shows the various locations where the motor has been, the departments to which it is charged or credited, and so on. On the lower half of the card is kept a record of the failures and repairs, by whom made and at what cost. Here again we have the complete life history of each motor at a glance. One file of these cards is located in the office of the Electrical Engineer and another in the office of the Mechanical Superintendent.

In the case of the 3-in. by 5-in. cards first mentioned, often the head of a department will wish to have a set of cards that list the machinery in his department. These two systems are very flexible, and can be altered in detail to meet any special conditions that may arise. Once installed they are easily kept up to date and will be found to be in constant use for reference.

Lawrence, Mass. A. J. CALHOUN.

Mechanical maintenance of

Power Drives

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through the auxiliary transmitting equipment to all driven machines.

Method of Mounting Lineshaft Coupled Directly to Motor

ORDINARILY a motor is connected to a lineshaft either by belt or by silent or roller chain. Generally this is because the lineshaft speed, if the shaft were direct-connected to the motor, would be far above ordinary operating practice. In some lines of work, however, it is desirable to have a high operating speed for the lineshaft because that will result in a lower reduction, or increment, in the ratio of the speed between the lineshaft and the machines it drives.

At the plant of the Star Woolen Co., Cohoes, N. Y., the high speed at which the cylinders in a new rag-picking machine are operated permitted connecting a lineshaft directly to the motor through a flexible coupling.

Because the old machines in this plant were replaced with larger types of machines, it was necessary not only to strengthen the floor to support the machines, but also the ceiling, for supporting the lineshafts and motors. Each of the two rag picker groups installed consists of four main cylinders. These are driven by four 20-hp., 1,165-r.p.m. Western Electric motors. Each motor drives two cylinders and operates under a heavy load practically continuously, day and night, for about 144 hr. per week. Each of the lineshafts is $2\frac{3}{16}$ in. in diameter and is supported on Fafnir double ball-bearing boxes and hangers, which are spaced on about 6-ft. centers. The motor is direct-connected to the end of the shaft through a Grundy flexible coupling (Chas. Bond Co., Philadelphia, Pa.). This gives practically a four-bearing suspension, taking the motor into consideration, with a flexible coupling between each of the two pairs of bearings. However, extreme care was exercised to see that the motor and the lineshaft were in perfect alignment.

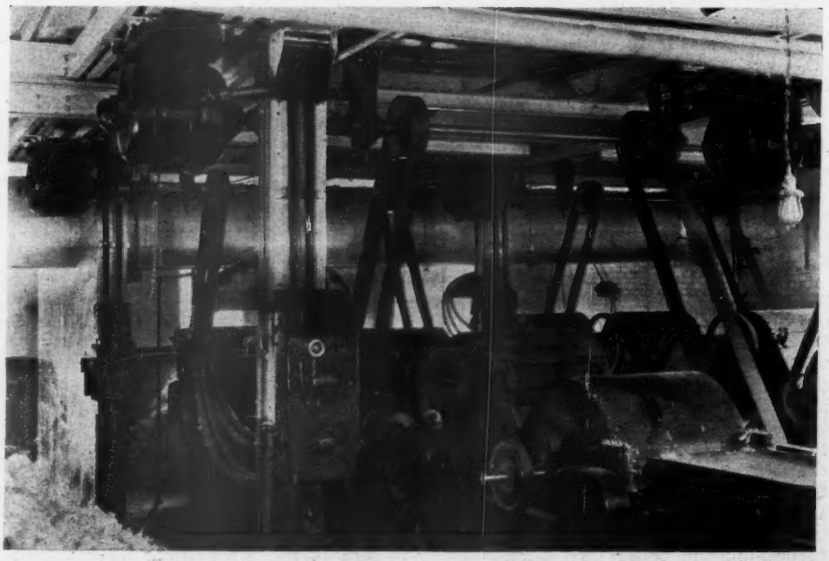
The picker cylinders weigh 750 lb., and are 36 in. in diameter and 14 in. wide. The driving motors bring them from rest to the operating speed, 1,000 r.p.m., in 20 sec. The compensators are of the G.E., totally-enclosed, CR 1034 type with push-button stop. All of the motors are of the induction, squirrel-cage type and operate on a three-phase, 40-cycle, 550-volt supply.

Two 4-in. leather belts from each lineshaft drive the two cylinders on a machine. The pulleys on the lineshaft are of cast iron, with solid rim and hub, and are 12 in. in diameter, with a 4-in. face. These are belted to 14-in. by 4-in. pulleys on the cylinders which give the speed reduction to 1,000 r.p.m. This installation has been in satisfactory operation for several months.

It was necessary to erect special steel work on the ceiling to support the motors and lineshafts. This consists of 8-in., 18-lb. I-beams with 6-in., 8-lb. channels as stringers. The channels are placed in pairs, back to back, 2 in. apart with pipe separators in between. These stringers serve as footings for supporting the lineshaft hangers and the motors.

It was also necessary to take up the flooring and strengthen it to support the machines. This was done by inserting 10-in. by 10-in. beams for the machines to rest on in place of the 3-in. by 10-in. stringers previously built in the floor. They were, of course, braced from beneath. These large beams and the stringers were of the same height and so did not interfere with laying the flooring.

THEO. P. BARNUM.
Vice-President and Secretary,
Barnum Bros. Co.,
Troy, N. Y.



These motors are direct-connected through flexible couplings to the ball-bearing lineshaft.

This illustration shows the corner of the picker room at the Star Woolen Co. The construction for supporting the motors is shown overhead at the left. Similar construction is used to support the lineshaft hangers with Fafnir double ball-bearing hanger boxes. Grundy flexible couplings were used between the motor and the lineshaft. The rag picking machine is operated at 1,000 r.p.m., while the motor drives the lineshaft at 1,165 r.p.m. This necessitates only a slight reduction in speed and permits the use of pulleys of large diameter.

Useful Chart for Determining Power Transmitted by Friction Wheels

HORSEPOWER transmitted by friction disks or wheels of different composition when used against cast-iron surfaces may be quickly determined by means of the accompanying chart. Only two simple operations are required in using this chart. How the horsepower transmitted is determined is easily explained by an example. For instance, if the width of the friction face of a wheel is 3 in., the mean diameter 20 in., and if it turns at 1,000 r.p.m., what horsepower will be transmitted by a leather fiber wheel bearing on a cast-iron wheel?

The two dotted lines drawn across the chart show how this example is solved. First, extend a straight line through the 3 (the width of the face), in column *A*, and the 20 (mean diameter of the wheel), in column *B*, and locate the point of intersection with column *C*. From that point of intersection, extend another straight line over to 1,000 (r.p.m.), in column *E*; the intersection of this line with column *D* gives the answer as 42.8 hp.

Between columns *C* and *D* are shown other combinations such as tarred fiber on cast iron, straw fiber on cast iron, and so on. When such combinations are used, find the point of intersection with column *D* in the same manner as before and then measure upward from the intersection the distance indicated by the corresponding arrows for the particular computation; the top point

thus located in column *D* gives the horsepower that will be transmitted, using the combination mentioned. In other words, the length of the arrow indicates the amount to be subtracted in each case because the other friction surfaces have lower transmitting capacity than leather fiber on cast iron. Thus, for example, tarred fiber on cast iron will transmit 33 hp., straw fiber on cast iron, 18 hp., wood on cast iron, 10.8 hp., leather on cast iron, 9.6 hp., and a cork composition on cast iron, 4.8 hp. These figures are readily checked on the chart by measuring upward the distances indicated.

The term "mean diameter" is used in column *B*, as in the case of bevel or miter wheels, the mid-diameter should be used rather than either extreme.

This chart is based on the following rule: To find the horsepower that may be transmitted by spur, miter or bevel friction drives, multiply the effective width of the face in inches by the mean diameter of the wheel in inches, then by the number of revolutions per minute made by the wheel and then by 0.00071. The result is the horsepower transmitted by a leather fiber wheel bearing on a cast-iron wheel. Where other compositions are employed in place of leather fiber, use the following constants instead of 0.00071:

Tarred fiber on cast iron...	0.00055
Straw fiber on cast iron.....	0.00030
Wood on cast iron.....	0.00018
Leather on cast iron.....	0.00016
Cork product on cast iron...	0.00008

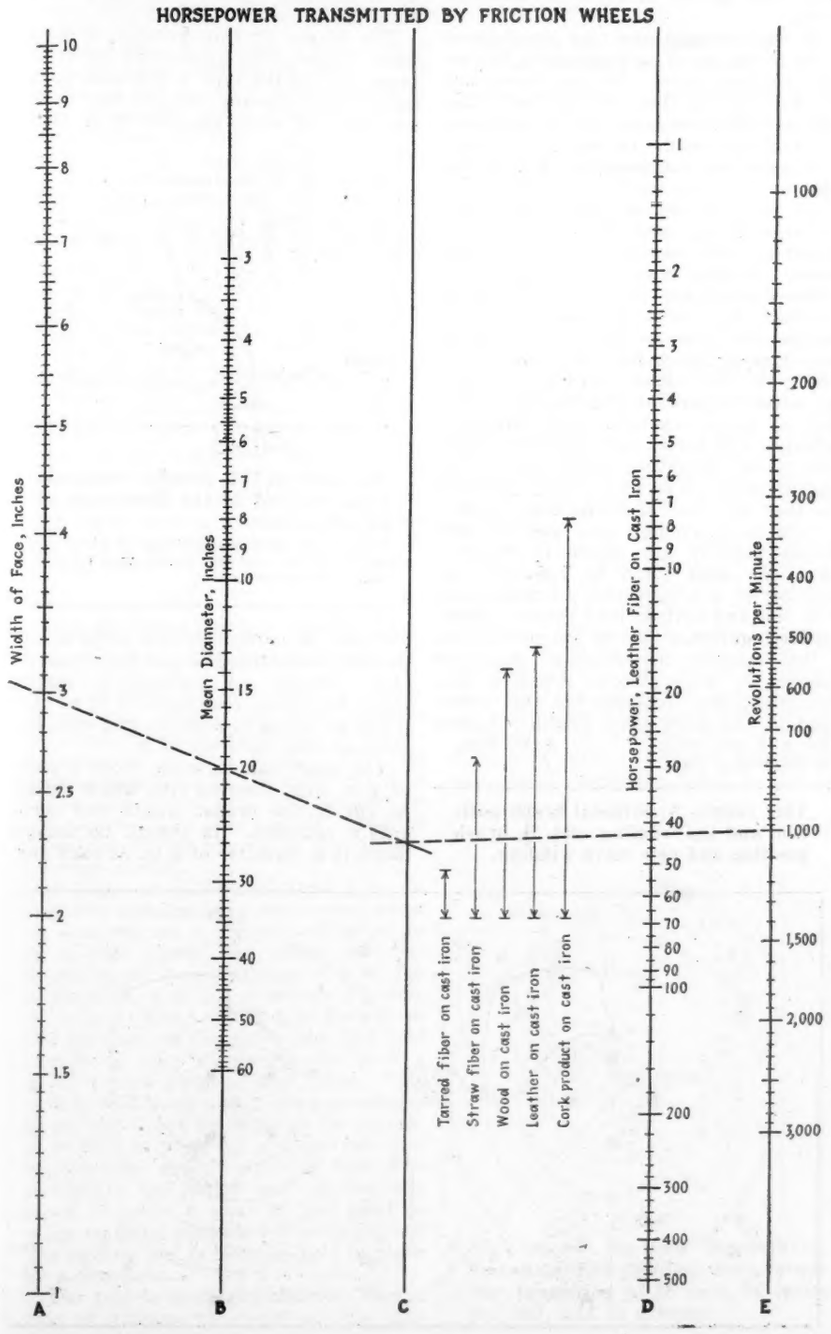
This chart may also be used in the reverse order; that is, where the horsepower, mean diameter, and revolutions are known, and it is desired to determine the proper width of face, begin at the right and the width will be found in column *A*. Correspondingly, when any three factors are known, the fourth may quickly be found.

W. F. SCHAPHORST.

Mechanical Engineer,
Newark, N. J.

With this chart the horsepower transmitted by friction disks of various composition, bearing on cast iron, may be easily determined.

In the example shown, a leather fiber friction faced wheel 3 in. wide (*A*) and 20 in. in diameter (*B*) operating at 1,000 r.p.m. will deliver (*D*) 42.8 hp. To get the horsepower transmitted by wheels of other composition, bearing on cast iron, proceed as with leather fiber but measure up (subtract) from the intersection on (*D*) the length of the arrow indicated opposite each composition.



Individual and Small Group Machine Drives Prove Economical

COMPLETE electrification proved to be cheaper than the cost of a new boiler for Andrew Cook & Sons' sawmill in Newcastle, New South Wales, Australia. This mill was steam-engine driven and one of the principal arguments advanced against electrification was the fact that fuel cost practically nothing. Sawdust and shavings were burned and what little coal was used was mixed with these.

When a boiler at this plant was condemned recently a test was made by the Australian General Electric Co. to obtain definite figures on the comparative cost of steam engine and motor drives. The first motor installed showed that 17 hp. was being absorbed in the lineshaft. In order to improve this condition, a general rearrangement of machines was made, that involved subdividing the grouping of machines and the installation of individual and small-group drives.

The present motorization of the plant includes (*a*) a 50-hp. motor driving a 36- to 42-in. circular saw and four side planer; (*b*) a 25-hp. motor driving a bandsaw; (*c*) a 20-hp. motor driving the joiner shop of eight machines; (*d*) a 7½-hp. motor driving a docking saw, wood lathe and saw sharpener, and (*e*) a ½-hp. motor driving an emery wheel and a saw tensioning machine. General Electric motors are used.

One of the interesting points in the installation is the use of individual watt-hour meters and ammeters on each motor in order that the cost of operating each machine or group may be ascertained.

The cost of operating the mill with steam as one large group drive was approximately $400 per month; now the cost of operating it with the machines driven individually or in small groups, costs approximately $180 per month. In addition, the output of the mill has been increased 25 per cent as a result of the rearrangement.

Since this change has been made in the method of driving the plant, the management of a second sawmill has decided to change over to a similar subdivision of the drive to the equipment, with similar control and individual metering.

In the Repair Shop

This section is devoted to repair work on electrical and mechanical equipment. Special attention is given to shop or bench tools and short cuts or improved methods of handling work of this character. Contributions are always welcome.

Method of Demagnetizing a Watch in a D.C. Magnetic Field

RECENTLY I had occasion to install a piece of machinery coupled to a motor by means of a magnetic clutch. During the operation my watch became magnetized and because it was needed badly, recalled to mind an old stunt.

The watch was hung on a heavy piece of twine about 3 ft. in length, which was then twisted with as many turns as it would stand without tangling. With the clutch in operation, the watch was suspended in mid-air and allowed to rotate as the twine unwound, dropping it slowly past the clutch. The watch was demagnetized and gave no further trouble. Any d.c. magnetic field could be used to obtain the same effect.

The same method can also be used in the case of tools and other small objects which are bothersome when they become magnetized.

Chief Engineer, PHILIP N. EMIGH.
The Mountain Water Supply Co.
Indian Creek, Pa.

Changing Brush Position and Type of Winding on D. C. Motors

IN REPAIRING an old direct-current motor, it was found necessary to eliminate two features of design that had given considerable trouble. The armature of this machine had a number of burned-out coils, which had been cut open and jumpers put on the commutator bars. This patching process had been carried on until the armature winding became overloaded and burned out completely.

The electrician at the plant in which the motor operated stated that he had experienced considerable trouble with the brushes sticking in the brush box of the lower brush-holder and asked us to change the brush position if possib'e when rewinding the armature.

We found that the brush-holders were located on the vertical and hori zontal lines as shown in diagram *A* of the illustration, and that oil had leaked past the bearing and collected on the lower brush-holder. This oil had become gummy and caused the brush to stick, with sparking as a result.

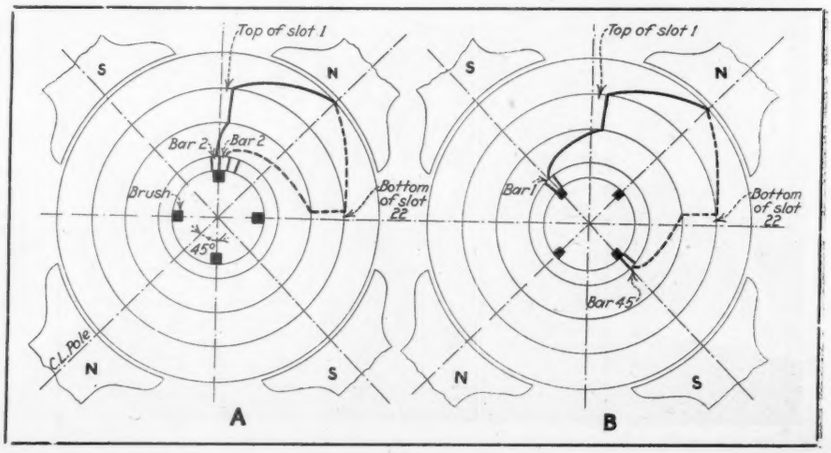
The armature was checked and the data found to be as follows: 87 slots, 87 bars, lap winding, coil pitch 1-and-22, with the top leads connected straight out and all the throw in the bottom leads as shown in diagram *A*. There were 87 diamond-shaped, pulled coils, each wound with six turns of No. 12 d.c.c. round wire. These coils were built up two wires wide by three deep, and were what is termed cross-overs; that is, the coils were wound on a shuttle with one wire in hand and the cross-over placed at the front diamond point.

It was thought that the cross-overs were the cause of so many coils becoming short-circuited. On the front end of the winding there was a band that appeared to have been put on with considerable pounding to shape the ends; this pounding had weakened the insulation on the wire at the cross-over.

It was decided to move the brush position 45 deg. and change to a wave winding. The reason for choosing the wave winding was to eliminate the cross-over in the coils. A two-circuit winding has twice as many coils in series per path as the corresponding lap winding; therefore, we could wind the coils with three turns of two No. 12 wires in parallel, reducing the number of turns one-half, thus making a cheaper and better coil, and still retain the same operating conditions. The commutator necks had to be milled out to take the No. 12 wires four deep.

The wave winding data and the new brush position are shown in diagram *B*. The lead pitch is 1-and-45, resulting in a progressive winding, with the top and bottom lead throws evenly spaced on either side of the center line.

By making the changes described above, we were able to eliminate two unsatisfactory features of the motor and at the same time produce a good job at a low cost. A. C. ROE.
Wilkinsburg, Pa.

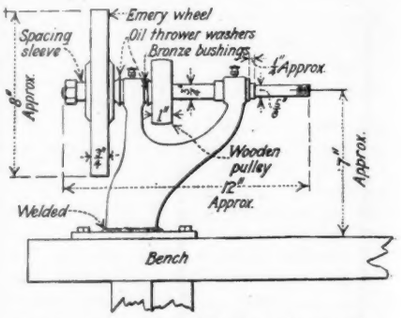


This shows, A, original brush position and lap winding and, B, brush position and new wave winding.

Inexpensive Grinder Made From Automobile Parts

AN EXAMPLE of what may be done with discarded automobile parts when necessity demands the use of material at hand, is shown by the grinder described below.

The frame of this grinder is made from a discarded automobile or truck front axle of the type which uses bushings in the steering knuckle bolt holes. Saw this off approximately 7 in. from one end; be careful to saw along a line parallel with the holes in the opposite end. Obtain an automobile spring plate, which has four holes in it, so that it can be bolted to a bench, and weld the piece of axle securely to it.



The frame of this grinder was made from one end of the front axle of an automobile.

The shaft was made from a piece of steering rod, and the pulley was turned out of hardwood.

The shaft can be made from a piece of ¾-in. solid steering rod, which should be cut to the proper length and accurate'y centered. It should be turned down to a diameter of § in. at each end,

leaving a shoulder approximately ¼-in. wide outside the bearing. If necessary, true the part between the two shoulders, but do not turn it down any more than necessary. Both ends of the shaft should be threaded in the lathe and fitted with nuts which should, while screwed on the shaft, be faced on the side to clamp the wheel. The oil thrower washers should be made with a force fit, so that they will turn with the shaft, and mounted in the ¼-in. space left between the shoulders and outer end of the bearings. They should be beveled as shown to keep oil off the grinding wheel and pulley and can be made from discarded bronze bushings having a flange. The emery wheel washers may be made of cast iron; the inside washer should be a tight force or shrink fit and afterwards turned true.

A wooden pulley can be turned down from walnut or other hardwood and held on the shaft by a machine screw threaded into the wood, which clamps on a flat place filed on the shaft. This pulley should be made after determining the proper speed required by the emery wheel selected.

Oil holes should contain a small piece of felt wick which touches the shaft. This admits oil gradually and also strains it. Bearings should be fitted accurately, finished with an expanding reamer and should be in proper alignment. If the holes in the axle are out of line, the bearings can be made self-aligning and secured by a setscrew.

A ⅓- or ¼-hp. motor, set on a bench at the rear of the grinder and belted to it with a 1-in. or 1½-in. belt will operate it satisfactorily. The grinder described has been in use for over one year and no wear can be detected in the bearings. Owing to the fact that it was made with a small amount of labor and from waste material, this grinder has been worth many times what it cost.

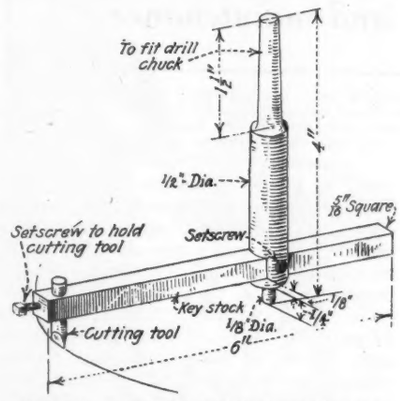
Durant, Okla. J. P. KINCAID.

Simple Time-Saving Device for Cutting Fiber Washers

IN ORDER to save time, a simple tool for cutting out fiber washers was recently made which has proved indispensable in our work. The old method used was to cut them out in a lathe, and was a very slow process in comparison with the results obtained from the device shown in the accompanying sketch.

A piece of cold-rolled steel ½ in. in diameter and 4 in. long was turned down on one end for a distance of 1½ in. to fit a drill chuck; the other end was turned down to a diameter of ⅜ in. for a distance of ¼ in., to act as a guide. A 5/16-in. hole was drilled ¾ in. back from the shoulder on the guide end, and filed square to take an arm made from a 5/16-in. square piece of key stock. This arm is 6 in. long and is given a sliding fit so that it can be adjusted for length. It is held in place by a 5/16-in. setscrew in the steel shaft. Another hole was drilled in the outer end of the key stock to insert a piece of tool steel or other material suitable for cutting fiber. The cutting tool is likewise held in place by a setscrew.

The tool is used as follows: Use a pair of dividers to scribe out the size of washers desired. Then drill a ⅜-in. hole in the center of each washer, which is already centered by the pivot of the dividers. Set the tool to cut the outside diameter first; then, after as many



Here is a tool that will simplify the job of cutting fiber washers.

washers as are required have been cut, set the tool for the inside diameter.

Any size of washer from ¾-in. up to 5-in. bore can easily be made in this way. There is always a demand for fiber washers in repair shops; so a tool of this sort which requires only 1½ hr. to make, will soon save its cost many times over.

NICHOLAS J. WEISS.

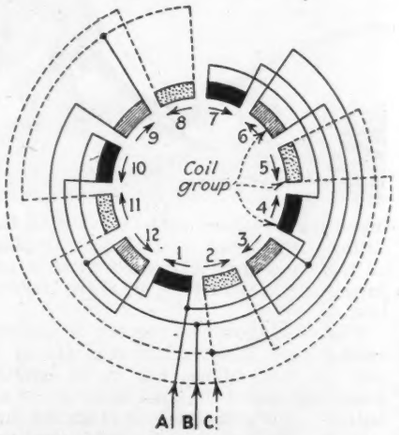
West New York, N. J.

Calculating New Winding for Small Induction Motor

IN CALCULATING a new winding for a small induction motor from which the old winding had been removed, the following procedure was followed:

The rating of this motor as shown on the nameplate was three phase, 60 cycles, 220 volts, 8.35 amp., 1,800 r.p.m., and 3 hp. The number of poles equals (120 × frequency) ÷ r.p.m. = (120 × 60) ÷ 1,800 = 4. For a full-pitch winding the coil span would be equal to 36 ÷ 4 = 9, since the stator had 36 slots and this was a four-pole machine.

Using a delta connection, the phase voltage is equal to the line voltage and the phase current is equal to the line current divided by 1.73. Two constants must be used; the number of volts per turn, $V_t = 1$, and the circ.mil per amp. = 550.



This shows the new three-phase, four-pole, two-parallel, delta winding, consisting of 36 coils, 36 turns per coil, and 12 groups.

As we had a large supply of No. 19 d.c.c. and enameled wire, which has an area of 1,288 circ.mils, it was decided to use it, if possible. Phase current for a delta connection is 8.35 ÷ 1.73 = 4.82 amp., and using 550 circ.mils per amp., the total area required would equal 550 × 4.82 = 2,650 circ.mil. Two No. 19 wires in parallel have an area of 2 × 1,288 = 2,576 circ.mils which is close enough for all practical purposes. By using the two wires in parallel, a two-parallel, delta connection may be used.

Then $V_t = 1 = 220 \div (2 \times 3 \times N)$, or $N = 220 \div 6 = 36.6$ turns per coil.

The accompanying diagram shows the four-pole, two-parallel, delta-connected winding, in which there are 12 pole-phase groups. Two groups are in series and the line voltage is impressed across them. There are 12 groups and 36 coils which allows three coils to be connected in series per group.

If it were considered desirable to chord the winding, the number of turns would have to be increased slightly and the span decreased. If the coil span is eight slots, the chord factor equals the sin of ⅛ (180 × 8/9) = sin of 80 deg. = 0.9848. The number of turns in a coil for a full-pitch winding must be divided by 0.9848 to obtain the number of turns to use for a span of eight slots; that is, $N = 36.6 \div 0.9848 = 37.2$, or 37 turns per coil.

Values used for volts per turn and circ.mils per amp. will depend upon the speed of the motor and the kind of frame, that is, whether open or closed.

CHAS. F. CAMERON.

Rock Springs, Wyo.

How to Prevent Bending Armature Shaft When Forcing Commutator On

THE lesson I learned from a mistake which nearly cost me my first job in a repair shop, may be of interest to other readers of INDUSTRIAL ENGINEER.

One day I was using a hydraulic press to force a commutator on a small core with a long shaft, applying pressure directly to the end of the shaft. The commutator fitted so tightly that I had to apply a good deal of pressure, with the result that I bent the shaft badly. Of course, that meant considerable extra work and I did not blame the foreman for getting angry at me. Since then I have always placed over the shaft a piece of pipe that is longer than the shaft itself, and have had no more trouble.

Repairmen do not always realize that the shaft of a small motor is rather easily bent and it is not an easy matter to get it straight again. If armature cores of any size are handled roughly or allowed to drop on the floor there is danger of not only bending the shaft, but also of burring or otherwise injuring the laminations. Such injuries may be the unsuspected cause of heating of the armature, due to eddy currents.

Newark, N. J. SAMUEL CARBAT.

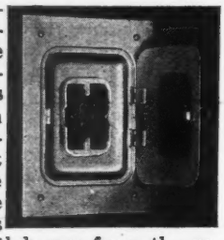
New Equipment

for plant operation and maintenance

Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

Safety Fuse Carrier

NEW features in safe switching and fusing are announced by the Mutual Electric & Machine Co., 7610 Jos. Campeau Ave., Detroit, Mich., in a new Bull Dog SAFtoFUSE (pronounced safe-to-fuse) fuse carrier, shown in the accompanying illustration. This unit is made in 30-amp. and 60-amp., 250-volt sizes. These fuse carriers have switch contacts which may be withdrawn from the receptacle base. When the carrier is in the "on" position, the fuse acts to fill the gap between the blade contacts, and the molded composition unit must be fully withdrawn before the fuses are accessible. The molded unit may also be inserted in the receptacle upside-down which shows the fuses exposed, but in this position they are dead. Suitable means are provided for testing fuses.



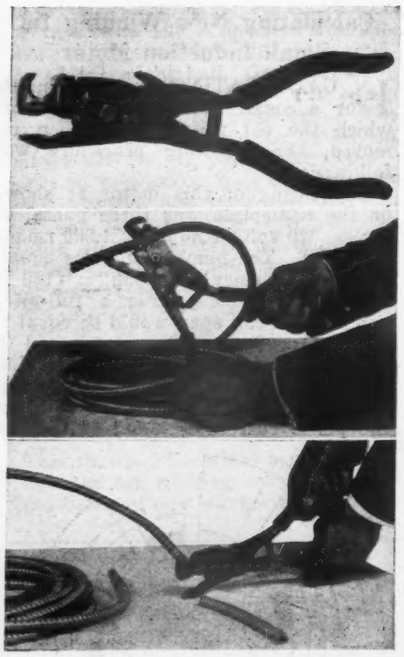
The types now being put on the market are enclosed in steel cabinets with luminized fronts. They are particularly adapted for industrial plants where safety in fusing, appearance and compactness are required. Bulletins 102, 103 and 104, which describe this equipment and its application, are now available.

Portable Air Compressor

INDUSTRIAL plants having use for compressed air and without piped air distribution will be interested in the new H. B portable compressed air unit which is announced by The Hobart Brothers Co., Box MS-5, Troy, Ohio. This unit may be used to supply air for cleaning machinery, motors, operating a paint spray as shown in the accompanying illustration, and other industrial purposes within its capacity. This unit is an H B silent, twin, heavy-duty, motor-driven compressor with a capacity of 8 cu.ft. per min. at 85 lb. maximum pressure. This equipment is mounted on a three-wheeled, rubber-tired truck with 25 ft. cable and a 15-gal. air tank. The paint spray gun, 25 ft. of hose and paint receptacles are included. The compressor can be furnished either with automatic start and stop pressure switch, or arranged for continuous operation at a given pressure.

Tool for Armored Cable

THE accompanying illustrations show the triangle armored cable tool, manufactured by the Triangle Conduit Co., Inc., Dry Harbor and Cooper Ave., Brooklyn, N. Y., and the method of operation. The manufacturer states that this tool has eliminated one of the difficulties experienced heretofore in



installing armored cable in that it facilitates the quick and clean stripping of the steel from the wire without injuring the conductors or their insulation.

The tool, shown at the top of the accompanying illustration, consists of a pair of steel pliers, 11½ in. in length, weighing only 2 lb., and operates on an entirely new principle. It is stated that it will strip any single-strip armored cable in sizes 14/2, 14/3 or 12/2 without any adjustment. The wireman slips the tool on the cable as shown in the center illustration, opens and closes the handles and the operation is complete except for sliding off the steel armor.

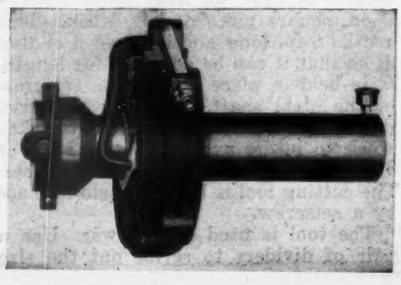
The tool also has an auxiliary pair of wide-mouth pliers with extra-heavy leverage, which, it is said, performs all the functions of ordinary gas pliers, as well as a cutting device which cuts wire, cable or non-metallic conduit up to ½ in. outside diameter, as shown in the lower illustration. Both blades are good for 10,000 to 15,000 cuts, it is stated.

Non-Refillable Plug Fuse

SEVERAL distinctive features are incorporated in a new, non-renewable plug fuse recently placed on the market by the Trico Fuse Manufacturing Co., Milwaukee, Wis., under the trade name of Cleartop. The fuse consists of a separate porcelain base and body. The base has a long baffle chamber which extends to the inside top of the body and holds the mica window in place. The body and base are held together by a heavy brass screw shell. The body is finished in a dull black, giving the appearance of molded insulation. Some of the distinctive features claimed for this fuse are, provision of a large, rugged knurl around the top edge to afford a good grip when tightening; the fusible strip has a restricted blowing portion; each strip has the rated current stamped plainly on the top and is visible through the mica window. A vent space is provided around the base so that the gases escape along the exterior of the base within the body and are gradually released along the base. The body and base are molded from a high grade of porcelain. The base supports the mica disk as well as the fuse strip and acts as a fireproof barrier to prevent interior flashovers. A large center contact is riveted to the base.

Compression Clutch

HERETOFORE the compression clutch shown in the accompanying illustration was made only for the manufacturers of machines. The Conway Clutch Co., 1935 West Sixth St., Cincinnati, Ohio, announces that this type of clutch will now be available for shop equipment drives. Features that have made this clutch desirable for severe conditions of service are said to be its easy engagement, quick release, idling without drag, and the ability to deliver power to the belt. The sleeve member is equipped with

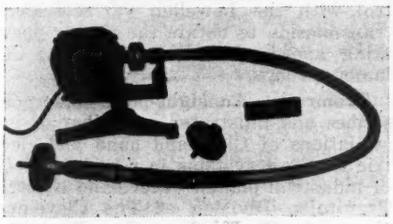


bronze bushings and has a full-length bearing for its over-all length.

These clutches range in power capacity from 1 to 50 hp. at 100 r.p.m.; the smaller sizes, it is stated, can be operated at speeds exceeding 600 r.p.m. Dimensions vary from 4 in. in length by 2⅛ in. in diameter for the sleeve, and 9½ in. over-all, to 12 in. in length by 5⅛ in. in diameter for the sleeve and 22½ in. over-all. Maximum bore for 1 hp. is 1⅞ in. and for 50 hp. it is 3⅛ in. The manufacturer states that all parts are easily accessible and the lever arm so constructed that any end thrust which the cone delivers is taken care of when the clutch engages. It is also stated that the friction band is a full-floating member which, in addition to delivering power, serves as the principal factor in release.

Flexible Power Unit

THE new flexible power unit shown in the accompanying illustration has been placed on the market by Sirianni & Trumbettas Mfg. Co., 110 Farview St., Carbondale, Pa. This unit comprises a motor and a flexible power shaft made



for driving interchangeable brushes, drills, grinding or buffing wheels, and other tools.

The core or driving element of the flexible shaft is constructed of tightly-wound steel wires. The manufacturer states that the ¼-in. size core will drive a ¼-in. drill in metal. The oil-tight protective covering of the core is of zinc-plated steel. Inside this casing is a coil of tempered flat steel wire which forms the bearing surface for the core or driver to ride upon. It is stated that this flexible shaft is capable of operating at 2,200 r.p.m.

The driving motor can be placed wherever desired. The unit is mounted on a swivel base which permits it to swing around in a complete circle. Ball bearings for the motor will be furnished on request. General uses for this unit are drilling, grinding, polishing, buffing, sanding, cleaning, and commutator slotting as well as removal of paint and rust.

Pipe Bending Vise

ANNOUNCEMENT is made that Paul W. Koch & Co., 33 S. Wells St., Chicago, Ill., are now marketing the new Jiffy pipe bender vise shown in an accompanying illustration, in which ½-in. and ¾-in. conduit may be cut, threaded, and bent without removing from the vise. As a vise it will take conduit up to 2 in. in diameter, although the construction of the vise is said to be much heavier than the standard 2-in. size.

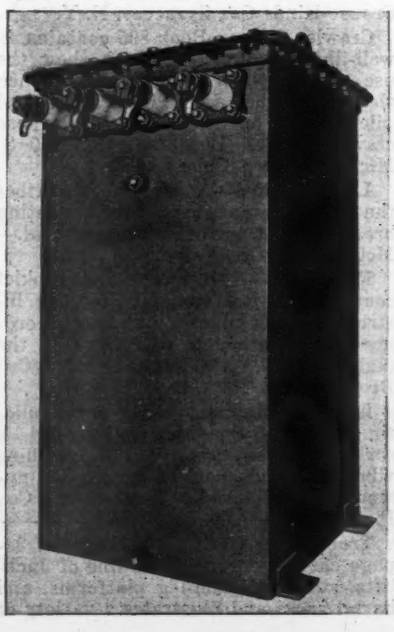
The bender is designed to make offsets, saddles, goose-necks and other difficult bends. It is adjustable for bending either downward or sidewise.

That it eliminates possible chances of injury by the hickey slipping or pipe breaking and also reduces, in some instances, the number of fittings required on the job, is also claimed.

The manufacturer also states that the bender does not flatten or kink the pipe as the forms and roller hold the pipe to shape and permit a radius as small as 2 in. without opening the seams. The operation is purely mechanical after the measurements have been taken. The vise is shipped in a box which is so arranged that it makes a permanent tool box for it.

Shovel-Type Transformer with Oil-Tight Tank

A NEW shovel-type transformer shown in an accompanying illustration has recently been designed and placed on the market by the Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa. The outstanding characteristics of this transformer are a heavy end-frame construction, a welded sheet-metal tank, and additional bracing to prevent the transformer



from sliding around inside the tank. This transformer has been designed for use in applications that require a transformer having oil-tight tank and bushings.

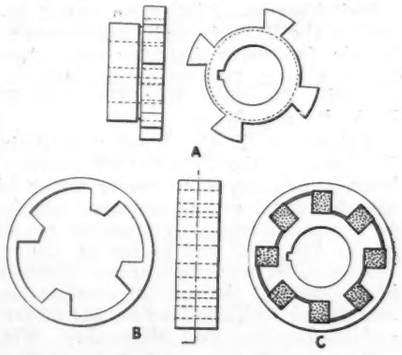
One specific application is on electrically operated shovels, which subject the transformer to vibration and shock. In such service the transformer is inclined at various angles which might cause leakage of oil and consequent overheating and injury if the ordinary type of distribution transformer were used.

Cement and flour mills where the fine dust finds its way into the ordinary transformers, and causes clogging of ventilating ducts, spoilage of oil and costly overheating of the transformer, and mine service and subway installations, are other suggested applications of this new shovel-type transformer.

These new transformers are manufactured at present for 2,300-volt, single-phase, 60-cycle, service, but it is possible to obtain them in other voltages.

New Flexible Coupling

EASE of assembly and disassembly are two of the advantages claimed for a new type of flexible coupling which has been placed on the market by The Clark Controller Company, 1146 152nd St., Cleveland, Ohio. This coupling consists of two duplicate flanges, as shown at *A* in the accompanying drawing, one outer sleeve, *B*, and eight pieces of resilient material, such as standard hydraulic packing. The flanges are keyed to the separate



shafts; the sleeve goes over the flanges and the resilient material is placed between the lugs on the flanges and sleeve respectively. The assembled coupling is shown at *C*. Steel springs and phosphor bronze retaining rings at each end of the outer sleeve hold the sleeve and packing in place. In this way the equipment is assembled without any projecting bolts.

It is stated that whenever it becomes necessary to change armatures on motor-driven applications, the retaining rings are removed, the sleeve slid back over one of the flanges, the packing removed and the armature with its half-couplings can then be lifted out. A spare armature shaft with a half-coupling of the same rating keyed on it can then be inserted quickly and the coupling re-assembled. It is also stated that the coupling is adaptable to reversing as well as non-reversing drives and also allows a large margin of angular and vertical misalignment as well as end float.

Trade Literature

you should know about

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

Threadless Conduit Fittings—An 80-page booklet entitled "The Story of the Kondu-Box," contains a description and listing of the various types of Kondu threadless, malleable-iron conduit fittings, gives a number of the advantages claimed for them, and illustrates many applications.—Erie Malleable Iron Co., Kondu Division, Erie, Pa.

Air Tools—In Booklet 131, which is entitled "Speed Up with Air," are shown applications of the various Sullivan air tools and air compressors.—Sullivan Machinery Co., 120 So. Michigan Ave., Chicago, Ill.

Capacitors — Bulletin GEA-352 contains nine interesting reports on the use of Capacitors for power factor correction and indicates the savings made possible in each case.—General Electric Co., Schenectady, N. Y.

Speed Measuring Instruments—Bulletin 1105 describes the Jagabi speed indicator, and hand tachometers, tachoscopes and tachographs for the accurate indication, measurement, and recording of speeds.—James G. Biddle, 1211-13 Arch St., Philadelphia, Pa.

Switchboards—Publication 1006-2 describes the line of Condit built switchboards for every industry and illustrates a large number of applications.—Condit Electrical Mfg. Corp., Hyde Park, Boston, Mass.

Automatic D.-C. Starter—Bulletin 215 describes the Type C-1220, current-limit, automatic, d.-c. starter which is used for starting constant-speed, shunt- or compound-wound motors up to 30 hp. at 115 volts and 50 hp. at 230 or 500 volts, for any applications where it is desired that the time of acceleration correspond with the load on the motor.—Allen-Bradley Co., Milwaukee, Wis.

Pressure Blowers and Exhausters—Bulletin 1608 describes the A B C special blowers and exhausters for mines, cupolas, forges, furnaces, and other applications. These are built in standard sizes to deliver pressures up to 12 oz. per sq.in.; special blowers are designed for pressures up to 24 oz.—American Blower Co., Detroit, Mich.

Watthour Meters—Bulletin 70 is a book of instructions on the installation and operation of Sangamo Type H single- and polyphase watthour meters. Numerous connections are shown by diagrams. — Sangamo Electric Co., Springfield, Ill.

Unit Heaters—An 8-page folder discusses floor mounting versus overhead suspension of unit heaters in industrial plants, illustrates the circulation of heat from both, and discusses where each type may be used to best advantage.—York Heating & Ventilating Corp., 1502 Locust St., Philadelphia, Pa.

Air Compressors—The 16-page Form 126, describes and illustrates the construction and operation of Pennsylvania duplex, single-stage and two-stage, cross-compound air compressors.—Pennsylvania Pump & Compressor Co., Easton, Pa.

Dust Mask—A folder describes the use of the Epco dust mask for cleaning and maintenance work in dusty locations. This consists of a hood with respirator and non-shatterable vision glasses.—The Engineering Products Corp., Inc., 64 Wall St., New York City.

Mica Undercutting Machines—An 8-page booklet illustrates, describes and gives the advantages claimed for the types Nos. 2, 6 and 9 of the Hullhorst mica undercutting machine, together with a description and price list of the Hullhorst small-disc mica cutters.—The Hullhorst Micro Tool Co., Dept. 2, Toledo, Ohio.

Disconnecting Hanger—Catalog E-26 illustrates the use, shows various models, and describes several of the various methods of installing the Thompson safety lowering switch or disconnecting hanger for lamp maintenance.—The Thompson Electric Co., 1438 W. 9th St., Cleveland, Ohio.

Pyrometers—A 68-page booklet entitled "Instructions for Installation and Care of Thermo-Electric Pyrometers" discusses the thermo-electric pyrometer, its installation, and the checking of pyrometer installations. This booklet is illustrated with numerous diagrams and photographs.—The Brown Instrument Co., Wayne and Windrim Aves., Philadelphia, Pa.

Conduit Fittings—Folder 30 illustrates and describes the line of Crouse-Hinds condulets with fuse cutouts.—Crouse-Hinds Co., Syracuse, N. Y.

Crawler Crane—Book 895 contains 48 well-illustrated pages, which show the use of dragline, dipper and trench shovel, skimmer scoop, hook blocks and pile driver on the new All-Purpose crawler crane.—Link Belt Co., 910 S. Michigan Ave., Chicago, Ill.

Lamp Guard—A circular describes the Loxon lamp guard for preventing breakage and unauthorized removal.—McGill Mfg. Co., Valparaiso, Ind.

Recorder — An interesting booklet compares the records made by Tag instruments to a plant newspaper recording all operation of equipment in the plant.—C. J. Hagliabue Mfg. Co., Brooklyn, N. Y.

Isolating Material—A 12-page bulletin describes the use of Korfund, a cork insulation, for isolating machine vibrations and shows diagrams of numerous installations.—The Korfund Co., Inc., New York, N. Y.

Trucks and Tiering Machines—A 32-page catalog describes the line of Jacklifts, stackers, steel-leg platforms, and barrel racks and illustrates a variety of applications of this equipment in different industrial works. — Lewis-Shepard Co., Watertown Station, Boston, Mass.

Vapor-Proof Electrical Fixtures—Bulletin A describes the interchangeable line of vapor-proof electrical fixtures and watertight conduit boxes and fittings for industrial, railroad and marine service.—Seidler-Miner Co., 316 E. Jefferson Ave., Detroit, Mich.

Steel Poles—A 36-page catalog describes the Truscon copper-alloy steel poles and gives considerable engineering data on their use for erecting transmission lines or in building substations.—Truscon Steel Co., Youngstown, Ohio.

Floodlight Projectors—Folder 33 and Bulletin 2083 describe the construction and illustrate a number of applications of the Imperial short-range floodlight projector. — Crouse-Hinds Co., Syracuse, N. Y.

Transformer Data—No. 7 of a series of monthly bulletins of technical information on transformers gives diagrams and an explanation of the use of the delta connection.—Moloney Electric Co., St. Louis, Mo.

Variable-Speed Transmission—A circular discusses the use of remote control with the Lewellen variable-speed transmission to obtain the proper operating speed.—Lewellen Mfg. Co., Columbus, Ind.

Tramrails—An eight-page folder describes and illustrates a number of installations of Cleveland hand and electric tramrail systems in a wide variety of industrial plants.—Cleveland Electric Tramrails, Division of The Cleveland Crane & Engineering Co., Wickliffe, Ohio.

Cable End Bells — An eight-page booklet gives a number of the salient features of the Three E indoor and outdoor cable end bells and illustrates a number of the types.—Electrical Engineers Equipment Co., Chicago, Ill.

Blow Torch—A circular describes the Unique gasoline blow torch and firepot.—Unique Mfg. Co., 113 N. Desplaines St., Chicago, Ill.

Lifting Jacks — A circular describes the Duff governor-controlled, ball-bearing, self-lowering jack, which is made in capacities of 15 to 50 tons.—The Duff Mfg. Co., Pittsburgh, Pa.

Speed Reducer—A catalog of the Lipe Products, describes the speed reducer which is built in standard gear ratios of 4:1 to 100:1 and in special combination worm and spur gear units with ratios of 48:1 to 7,000:1, and in sizes up to a maximum load of 500 hp. This catalog also lists the Lipe electric hoists, flexible couplings and an internal geared conveyor pulley.—W. T. Lipe, Inc., 208 So. Geddes St., Syracuse, N. Y.

Lightning Arrester.—Bulletin 220 describes the Keystone expulsion type lightning arresters. — Electric Service Supplies Co., 50 Church St., New York, N. Y.

Industrial Control—A 160-page catalog GEA-257, includes a reprint of the industrial control section of the General Electric catalog, gives instructive matter on the care and operation of control devices, wiring diagrams of controls, reference tables, and other useful information. — General Electric Co., Schenectady, N. Y.